Armenian Power Sector 2002 Least Cost Plan

Appendices

January 24, 2003

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Contract No. LAG-I-00-98-00005-00

Task Order No. 824

January 24, 2003

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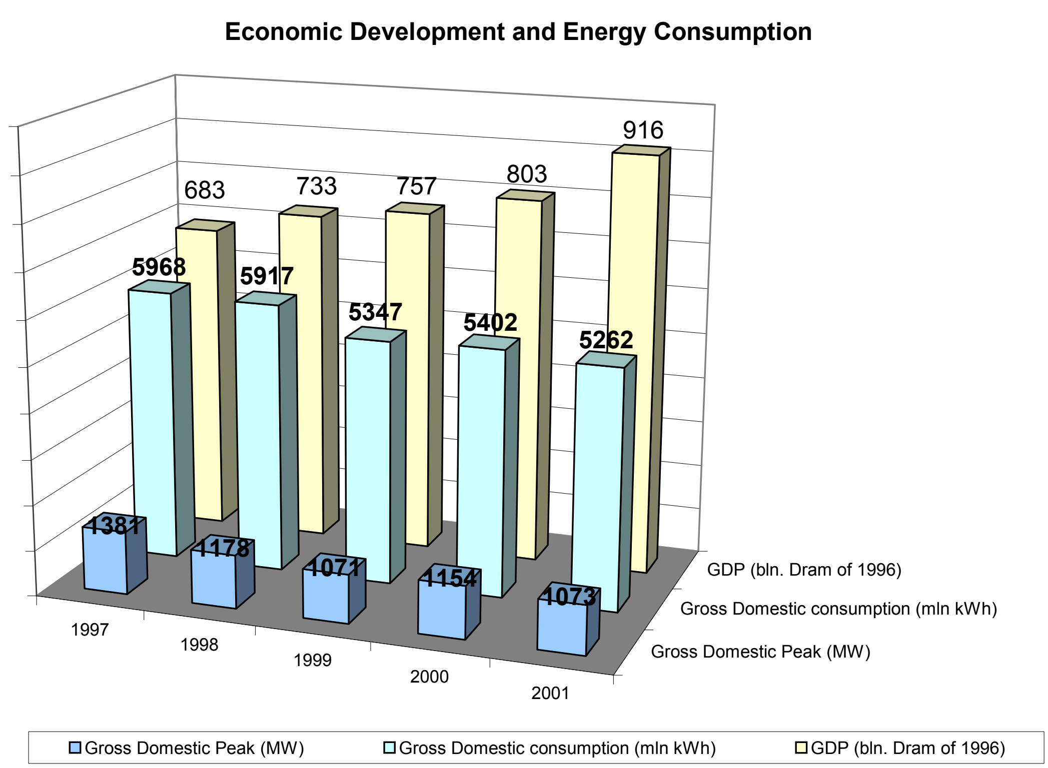
Version: 1.0

Economic development and energy consumption

Recent trends in the economic development and energy consumption are presented in Figure A.1. The graph shows the changes in Armenia gross domestic product against the domestic electric power consumption and system peak loads that were observed in 1997-2001. GDP is presented in 1996 billions of Drams to facilitate the comparison. The domestic electric power consumption and system peak load are expressed in mln kWh and MW respectively.

The graph in Figure A.1 clearly shows that there is no positive correlation between the level of economic production in the country and the electric energy consumption over this period. A number of reasons may explain such behavior, including the poor quality of statistics, which may be relevant for both the economic and electrical characteristics, or the presence of a prevailing tendency that overweighs positive trends in electric power consumption and may be caused by the reason that has not yet been involved into the analysis. Such phenomenon may be explained, for example, by continuing immigration from the country, which, given the dominating share of electricity consumption in the residential sector, can result in observed trends. However, the explanation of this phenomenon goes beyond the scope of this report, and the sole purpose of the graph was to illustrate the complexity of the task of forecasting under current economic conditions.

Figure A.1. Economic development and energy consumption



Review of forecasts done by other research groups

Several forecasts of electricity consumption have been developed by different international organizations. They reflect the variety of opinions on the future developments in Armenia as well as involve different methodologies. The summary of forecasts comparing the level of generation output and total system peak loads are presented in tables A.1 and A.2.

Table A.1. Forecasts of Generation Output (GWH)

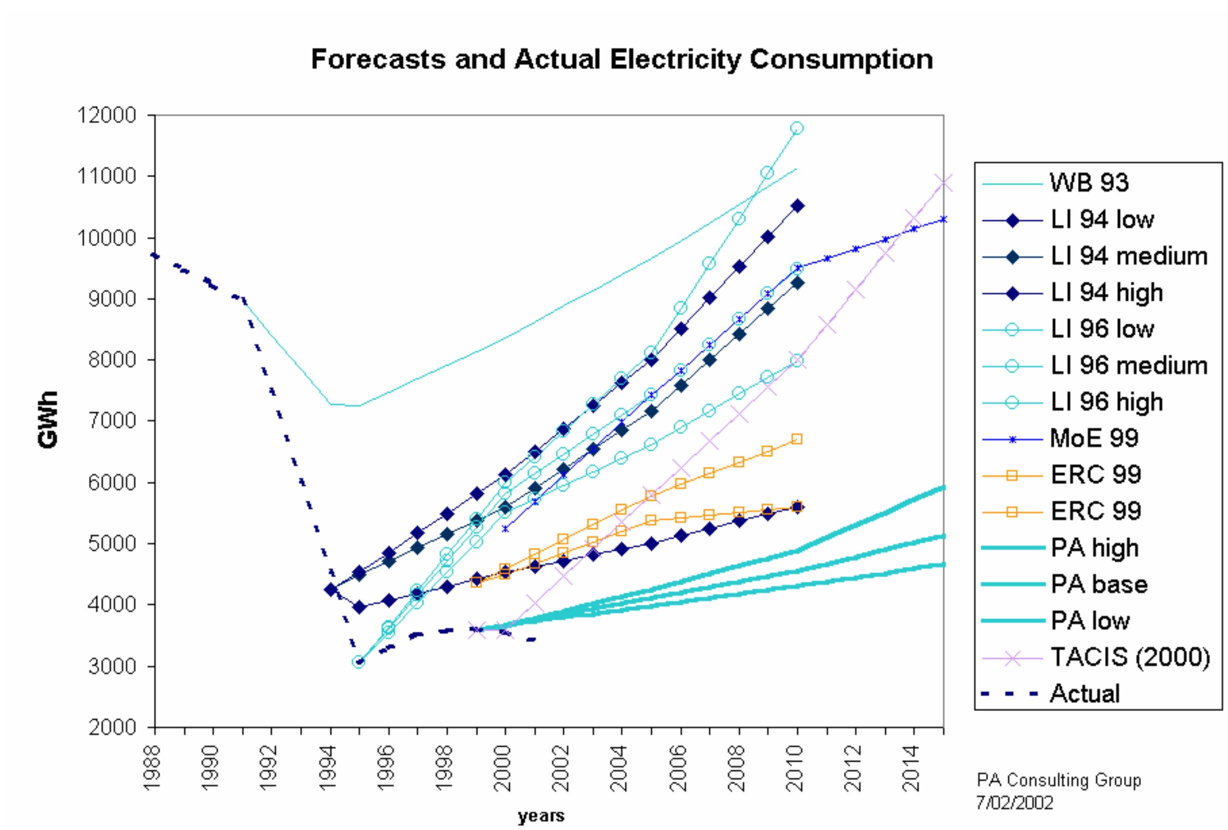
WORLD BANK (1993)							
	1995	**1996**	**2000**	**2005**	**2010**	**2015**	**2020**
Base	7252		8366	9651	11134		
LAHMEYER INTERNATIONAL (1994)							
	1995	**1996**	**2000**	**2005**	**2010**	**2015**	**2020**
Low	3971		4530	5012	5603		
Base	4486		5588	7175	9263		
High	4539		6128	8008	10523		
LAHMEYER INTERNATIONAL (1996)							
	1995	**1996**	**2000**	**2005**	**2010**	**2015**	**2020**
Low	3054	4518	5520	6620	7990		
Medium	4486	4518	5830	7420	9490		
High	4539	4518	5990	8120	11770		
MINISTRY OF ENERGY (1999)							
	1995	**1996**	**2000**	**2005**	**2010**	**2015**	**2020**
			5250	7420	9500	10300	11100
HAGLER BALLY (2000) TOTAL DOMESTIC CONSUMPTION							
	1995	**1996**	**2000**	**2005**	**2010**	**2015**	**2020**
Slow	3054	4518	3668	3996	4313	4664	
Medium	3054	4518	3666	4125	4553	5133	
High	3054	4518	3670	4259	4896	5937	
AEAI (2001) WITHOUT 25% REAL LOSSES (tech+non tech)							
	1995	**1996**	**2000**	**2005**	**2010**	**2015**	**2020**
Slow	3054	4518	3565	3850	4197	4574	4986
Medium	3054	4518	3565	3957	4392	4876	5412
High	3054	4518	3565	4031	4547	5297	6398

Table A.2. Forecasts of System Peak Load (MW)

	1995	1996	2000	2005	2010	2015	2020
ERC (1999)							
Medium			1070	1209	1431	1751	
High			1070	1138	1501	1860	
Hagler Bailly (2000)							
	1995	**1996**	**2000**	**2005**	**2010**	**2015**	**2020**
Low			1111	1209	1431	1751	
Medium			1109	1168	1308	1492	
High			1102	1124	1229	1352	

As follows from the tables, the forecasts fall into two different categories – those reflecting extremely optimistic point of view are typical of the early and mid-1990's, while more conservative approaches are found closer to the end of the decade. The reason for such overoptimistic vision of the future can be easily explained if one looks at the historical data on electricity consumption, which cover more distant past of Armenia. The graph is shown in Figure A.2.

Figure A.2. Forecasts and Actual Electricity Consumption



The forecasts developed in early 1990's tended to reproduce the trajectory of sharp decline in the electricity consumption that took place in late 1980's and ended in 1995 as the energy blockade of Armenia stopped and economic crises of 1994 was overcome. At that time it was considered that the recovery could achieve almost the same rate, but inverse sign, as the recent decline. This assumption is especially obvious from the forecast of Lahmeyer International done in 1996. But the next five years of the development of Armenia demonstrated that those hypotheses were far from reality. It is worth noting that the previous forecasts developed by PA in 2000 also failed to predict the dynamics of country's energy consumption. As the graph shows, the actual electricity consumption in 2001 fell short of even the low growth scenario considered in 2000.

The latest forecast developed by an official state agency was the ERC's projection of 1999. It was completed several months prior to the PA forecast and had, at the first glance, substantially different point of view on the future. Though the analysis of the ERC forecast conducted by PA showed that the discrepancy between PA's and ERC's opinions was caused by incompleteness of the data for 1999 used by the ERC because the ERC forecast was developed in the beginning of the year. PA recalculated the forecast of the ERC using complete year data. It turned out that the position of the Commission and the position of PA on system peak load were very close (Table A-2). Though, in terms of energy generation, the forecasts differed substantially which was explained by the fact that the ERC projected the development of energy intensive branches of economy while PA related future development with non-intensive branches and predicted faster growth in commercial sector.

The latest projections were performed by the AEAI in 2001. This forecast confirms the point of view of PA. The high and medium scenarios by AEAI correspond to the medium and low growth scenarios by PA.

Methodologies applied by other organizations

Limited information is available on the details of forecasting methodology applied by different organizations. The first forecast developed by the WB in 1993 was based on the aggregate energy intensity projection of the GDP. Applied to a well-established and stable economy, which does not experience structural transformation, this approach may be very successful. Under different conditions, it may lead to significant discrepancies between the reality and results of projections. LAHMEYER INTERNATIONAL (1994, 1996 update), and later the Ministry of Energy (1999) used MEDEE-S, the energy accounting model by sector. This model is based on the detailed simulation of the process of electrical energy consumption and requires a good deal of information on end-use consumption. As the later development of the country revealed, the assumptions that were taken as a basis for forecasting were far from reality so that they overweighed the accuracy of detail simulation of energy consumption in the model.

The Energy Regulatory Commission (1999) based its study on the data on energy usage by final process for residential sector. For the other types of customers, the projections for the electricity use were based mainly on the assumptions on growth rates.

In its previous edition of the Least Cost Generation Plan for Armenia in 2000, PA applied a combination of approaches. It developed a model by end-use for the residential sector. For other sectors, the electric energy intensity was calculated. After that, a number of hypothesis were developed to reflect future evolution of the intensities for each sector. A special module simulated feasible scenarios of economic growth that considered the development of each sector; total energy consumption was derived as a result of the economic activity level in each sector. System load shape was modeled in greater detail. The system load was synthesized out of the typical loads shapes for each customer class. It was used to determine the changes in overall system load curve caused by the different rates of economic development for different sectors. Changes in load factor were calculated for the synthesized system load curve and applied to the actual load curve to calculate the maximum load.

The most recent study by AEAI did not describe the methodology of forecasting. Therefore, it is reasonable to assume that the forecast was based on the set of assumptions regarding the consumption growth rates for different classes of electrical customers. Expert judgments were used as a basis for the assumptions. Under current conditions, such approach may prove to be very reasonable if the judgments are not politically biased. And on the contrary, it may lead to absolutely unreasonable results, if assumptions have nothing in common with reality.

PA approach to modeling

The overall approach to the modeling applied by PA in this study (2002 LCP) was driven by trends in energy consumption exhibited by different customer classes. Figure A.3 depicts the evolution of consumption volumes for residential customers, industrial customers, agriculture and the group of other consumers taken together.

Figure A.3. Recent Trends in Energy Consumption

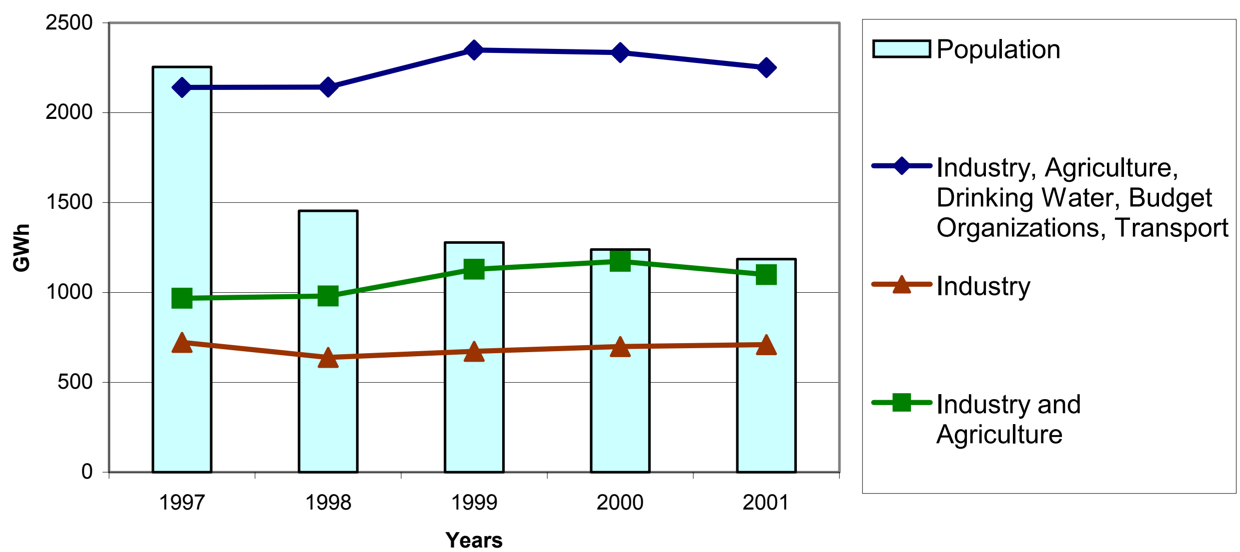


Figure A.3 was constructed based on the official data for consumption statistics. It demonstrates that starting with 1997, according to official data, metered volumes of energy consumed in the residential sector have been steadily declining. Contrary to that, the metered sales to industrial sector, agriculture, budget organizations, drinking water and transportation have stabilized and at least did not exhibit such an obvious decrease in the last five years. This observation became a basis for the construction of total approach to the modeling.

It was assumed that the main factor that drove down overall consumption of energy in the country was the continuing reduction of population, mainly caused by the outflow of immigrants from Armenia. Therefore, it was required to determine the magnitude of influence of the immigration on total electric energy needs of Armenia, clear out this amount to determine the relationship between the overall economic growth, consumption by other classes of customers and time. Relationships obtained through the described procedure were used to calculate the amounts of required electric energy in the long-run prospective.

Apart from the observed trends in consumption, several reasons explained the choice of the methodology, among which the most important were:

- The absence of reliable end-use statistics for electric power, the importance of which is very difficult to overestimate. Such statistics is fundamental for identification of the changes in consumption patterns for each customer class, or the impacts of energy efficiency and demand-side management programs on the overall system load shape. Similarly, the absence of this statistic impairs the identification of economically proven technologies with enhanced efficiency characteristics. The last study of the end use characteristics of electricity consumption was conducted by Resource Management Associates of Madison, Wis., in 1998 and has not been renewed since that time.
- Inaccuracy of electricity consumption statistics especially with regard to the lower levels of voltage. Combined with the lack of end-use data, it made any attempts to implement bottom-up approach to the forecasting of energy demand useless.
- Absence of any indications of changes in consumption patterns that might be considered as the significant features of the energy demand growth in the nearest future.

1. Methodology

The model developed for this study was intended to capture several important characteristics which drive overall energy consumption – the economic development, population and seasonality.

The level of economic activity and the structure of economy are represented in the model by Gross Domestic Product generated in industry, agriculture and all other sectors taken together. The GDP is given in constant prices of 1996 to eliminate effects of inflation.

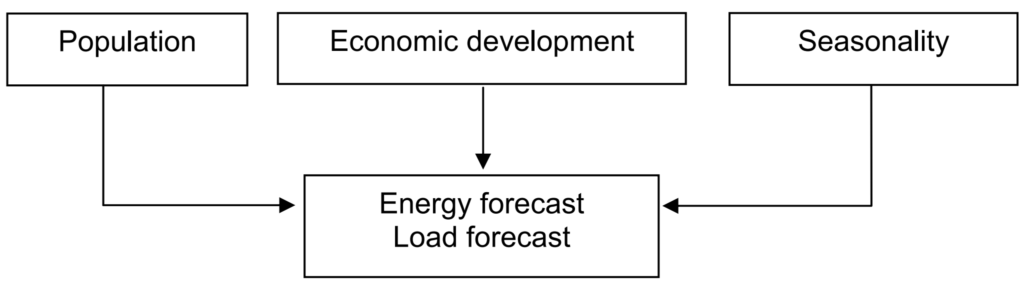
The relationship between energy consumption and population of Armenia is accounted for through the variable representing total number of residents and monthly energy consumption per household. The latter is differentiated by season.

The next important characteristic introduced into the model was seasonality of energy consumption. To take it into consideration, the model was built individually for each month and a special dummy variable was introduced. Therefore, individual equations were derived for January, February, etc, so that the complete set of equations consisted of twelve subsets representing each month of a year.

All drivers of energy consumption were simulated as time dependent series. Different alternatives were generated on the basis of combinations of considered parameters. Overall structure of the model is presented below. Though it seems simple, in reality the lack of reliable information substantially impaired the process of forecasting.

It is also important to stress that this model represents a top-down approach, therefore it does not project the consumption for each class of electric customers, which is typical for models built on the information by end use of electric power.

Figure A.4. Structure of the model



In the most generic form, the model consists of equations, which describe the dynamics of energy consumption, peak load, GDP produced in industry, agriculture and other sectors, energy losses and total population:

$E_{ti} = f(I_{ti}, A_{ti}, O_{ti}, LOSS_{ti}, R_t);$

$P_{ti}=P(E_{ti});$

$I_{ti}=I_0(1+R_{ind})^t\, Uind_{ti};$

$A_{ti}=A_0(1+R_{agr})^t\, Uagr_{ti};$

$O_{ti}=O_0(1+R_{oth})^t\, Uoth_{ti};$

$LOSS_{ti}=LOSS(I_{ti}, A_{ti}, O_{ti});$

$R_t = R(t);$

Where

E_{ti} - total energy consumption for domestic needs in kWh (without export/import exchanges, deliveries to Karabakh, Southern Georgia) for year t in month i;

P_{ti} - total system peak load for year t observed in month i;

I_{ti}	- GDP produced by industry for year t in month i, expressed in constant Drams of 1996;
A_{ti}	- GDP generated by agriculture for year t in month i, expressed in constant Drams of 1996;
O_{ti}	- GDP produced in all other sectors of economy for year t in month i, expressed in constant Drams of 1996;
$LOSS_{ti}$	- overall technical and commercial losses measured in kWh, observed for year t in month i;
R_t	- total population in Armenia in year t, which depends on natural birth rate and the rate of immigration not presented here for the sake of simplicity;
i=1,2,3,…,12	- index which denotes the month of a year;
t	- index to designate the year of considered time interval of simulation, which covers the period from 2003 till 2020;
R_{ind}, R_{agr}, R_{oth} -	average annual growth rates observed, respectively, in industry, agriculture and other sectors of economy during considered time interval;
$Uind_{ti}$, $Uagr_{ti}$, $Uoth_{ti}$	- stochastic variables which represent deviations from overall development trends for industry, agriculture and other branches of economy respectively.

For the dynamics of development for the industry, agriculture and other branches of economy, the regression was derived in logarithmic form. Therefore, forecasting functions were implemented in the model in exponential forms, e.g.

Ind_t = EXP ($\beta_0+\beta_1*T+\beta_2$), where β_2 – coefficient for dummy variable. When the regression was derived, the dummy variable was set to equal 1 for specific month and zero for all the rest.

Assumptions for population

It is important to stress, pertaining to the model, not the absolute values are essential, rather the tendencies to be observed in the future should be predicted correctly. From this stand point, it is more important to take realistic assumptions on the growth rates, rather than trying to determine the absolute values for the beginning of the considered time interval.

For the purposes of forecasting, it was assumed that the population would grow at average annual rate of 2%. Our assumption on dynamics of population also took into account the immigration rate which reached 6 individuals out of a thousand. The resulting dynamics of population is presented in Table A.3.

Table A.3. Forecast of Armenian Population

Year	1998	1999	2000	2001	2002	2003	2004	2005
Population	3421775	3409234	3344336	3336100	3396150	3441285	3487019	3533362
Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Population	3580320	3627903	3676117	3724973	3774478	3824641	3875470	3926975
Year	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Population	3979165	4032048	4085634	4139932	4194952	4250702	4307194	4364437
Year	**2022**							
Population	4422440							

Further steps of forecasting procedure

Assumptions on the evolution of population in the country was a starting point for the overall process. It consisted of several steps for deriving the equations of the model.

First, there was no data for monthly level of economic activity for the considered breakdown of the economy. On the other hand, consumption of electric energy reported by month for 1998 – 2001 for the industry, agriculture and all other structural consumers, registered in the balance of electrical energy, presented statistically significant series of data of 48 points each. The following operations were performed to use these time series data. First, for 1998-2001, the quarterly production of GDP in constant Drams of 1996 was calculated for industry, agriculture and all other branches taken together. Then on the basis of quarterly data for electric energy consumption the electric energy intensities for these branches were calculated. Thus, we received the electrical energy intensities for winter, spring, summer and autumn for the industry, agriculture, and other sectors. Then we assume that those intensities will remain constant for each season and applied them to monthly data on electricity consumption. Such a procedure provided the series of data on economic activity for each month. Time series analysis applied to these series produced the equations that incorporate both the long-term trends in economic development and the seasonality of economic growth.

Next step was to determine the relationship between the economic activity in each sector of the economy and losses in the system. It was done through the equation that related losses with the variables Ind, Agr and Oth.

The equation for population together with the dynamics of economic development by branches constituted the basis to derive the regression between total energy consumption, economic activity and time. That was done through double-step regression process. The first step related the overall consumption by structural customers with the population, and the residual was correlated to economic activity in the sectors and the losses.

The distribution of error was tested and confirmed that the model did not possess technical flaws: it had zero expected value, was normally distributed and the errors corresponding to different observations were uncorrelated with each other.

The system peak load was derived through computation of the load factor for 2001. It was assumed that the load factor would not change for the base scenario in the future.

Overall top-down econometric approach implemented for the modeling imposed several limitations on the capabilities of the model, including difficulties with the development of different strategies. To overcome them it was decided to accept several additional assumptions that were connected to the results of the previous forecast.

The slow and high growth scenarios developed in the 2000 LCP differed from the base scenario by -9% and +14% in terms of energy demand. For this study, it was decided to increase the variation. Thus for the slow growth scenario the energy consumption is lower than the base case by 12%. The high growth scenario is assumed to be by 36% percent higher than the base case. By its essence, the magnitude of such substantial differences are explained by the necessity to perform sensitivity analysis. These scenarios are not based on realistic assumptions that might come true in the future.

The assumptions on potential variations of peak load differ form those for the energy. For the high growth case it was assumed that the load factor for the system would grow by eight percent points comparing with the load factor for the base and low scenarios.

Example of equations from the model

To illustrate the result of regression analysis, some equations for January and February are presented below.

It is envisaged, that in January and February that industry will be develop according to the following formulas:

Ind_t = EXP (2.013+0.0061*T),

Ind_t = EXP(1.963+0.00618*T).

The positive sign of the coefficient for T demonstrates that the industry has been experiencing growth since 1997.

Similarly, the behavior of total losses in the system for these two months are described by the following equations:

$Losses_t$= 282 - 9.17*Ind_t - 1.14*Agr_t + 1.74*Oth_t,

$Losses_t$= 263 - 10.8*Ind_t - 1.24 *Agr_t + 1.77*$Oth_{t.}$

It is interesting to note that for all months in a year, the regression analysis revealed a negative correlation between the level of production in industry and agriculture, and positive correlation with all other sectors of economy.

Forecast of Domestic Consumption

Table A.4 presents the results of the forecasts for domestic consumption in Armenia that was calculated by the model.

Table A.4. Forecast of Domestic consumption of Armenia

Year	Medium Growth (mln kWh)	High Growth (mln kWh)	Low Growth (mln kWh)
2002	4490	4490	4490
2003	4181	4421	3587
2004	4229	5161	3734
2005	4264	5229	3762
2006	4299	5486	3789
2007	4335	5558	3817
2008	4371	5631	3846
2009	4408	5704	3875
2010	4446	5778	3904
2011	4484	5852	3933
2012	4523	5929	3967
2013	4562	6005	3999
2014	4602	6083	4032
2015	4642	6247	4066
2016	4683	6329	4100
2017	4724	6412	4133
2018	4766	6496	4167
2019	4809	6581	4202
2020	4852	6668	4237
2021	4896	6752	4272
2022	4941	6836	4308

For the next step of forecasting, the domestic consumption was complemented by the amount of export-import exchanges, which is presented in Table A.5. The table shows the volumes of maximum economically efficient annual power flows with the neighboring countries, which are based on the existing transmission capacities of the interconnections and optimal refueling schedule for the ANPP and maximum production on it. It turns out that existing transmission capacities of the interconnections can handle almost completely the total generation of the ANPP, so that it is uneconomical to invest in transmission lines.

Table A.5. Forecast of export-import exchanges

Year	Swap		Net-export to Artsakh &Kashatagh (GWh)	Export			Net-export from Armenia (GWh)
	to Iran (GWh)	from Iran (GWh)		Georgia (GWh)	Azerbaijan (GWh)	Turkey (GWh)	
2002	310.61	256.14	108.87	213.28	0.00	0.00	376.62
2003	255.00	225.00	97.98	220.00	0.00	0.00	347.98
2004	195.00	225.00	97.98	220.00	0.00	0.00	287.98
2005	270.00	220.00	99.94	220.00	0.00	0.00	369.94
2006	250.00	310.00	101.94	220.00	0.00	0.00	261.94
2007	285.00	240.00	103.98	220.00	0.00	0.00	368.98
2008	255.00	225.00	106.06	220.00	0.00	0.00	356.06
2009	195.00	225.00	108.18	220.00	0.00	0.00	298.18
2010	270.00	220.00	110.34	220.00	0.00	0.00	380.34
2011	250.00	310.00	112.55	220.00	0.00	0.00	272.55
2012	285.00	240.00	114.80	220.00	0.00	0.00	379.80
2013	255.00	225.00	117.10	220.00	0.00	0.00	367.10
2014	195.00	225.00	119.44	220.00	0.00	0.00	309.44
2015	0.00	0.00	121.83	220.00	0.00	0.00	341.83
2016	0.00	0.00	124.27	220.00	0.00	0.00	344.27
2017	0.00	0.00	126.75	220.00	0.00	0.00	346.75
2018	0.00	0.00	129.29	220.00	0.00	0.00	349.29
2019	0.00	0.00	131.87	220.00	0.00	0.00	351.87
2020	0.00	0.00	134.51	220.00	0.00	0.00	354.51
2021	0.00	0.00	137.20	220.00	0.00	0.00	357.20
2022	0.00	0.00	139.94	220.00	0.00	0.00	359.94

These figures were derived on the basis of assumptions as follows:

Assumption 1. Export to Azerbaijan and Turkey will remain 0 for the next 20 years.

The suggestion that after 2005 the exports to Georgia would reach 600 GWh per year to supply the energy to Turkey and Azerbaijan was rejected due to inadequate transmission capacity of the Georgian system.

Assumption 2. There will be no swap between Iran and Armenia after ANPP closure.

Assumption 3. The construction of new substation Agarak will increase reliability of parallel operation of the Armenian and Iranian power systems, but won't increase the amount of swap.

Assumption 4. Net export to Artsakh and Kashatagh is estimated to be equal to 106 GWh. It was assumed that in 2003 and 2004 the net exports to Artsakh and Kashatagh will decrease by 10% considering the fact that after privatization of distribution company by Midland Resources, the selling price for export to Artsakh will not be less than domestic price for electricity. Starting from 2005, net export to Artsakh and Kashatagh will be increased by 2%.

Assumption 5. Export to Georgia is estimated to be equal to 220 GWh for 2002 and next 20 years.

Forecast of the gross generation in the system was calculated with the use of the methodology of energy loss calculation applied by the Ministry of Energy. This methodology connects the gross generation in the system, auxiliary power consumption of power plants, amount of export-import deliveries, swap with Iran and losses in the high-voltage transmission networks as follows:

Net Generation = (Import from Iran * HVN Losses + Total Domestic Consumption+ Economic Needs of Power Plants + Net Exports)/(1-HVN Losses),

Gross Generation = Net Generation + Auxiliary Needs of Power Plants.

All variables are given in kWhs except for the losses, which are presented in percents.

To calculate the gross generation in the system it was assumed that:

1. Economic consumption of power plants would remain at the current level, which equal 44 mln kWh per year.
2. In ten years the losses in high-voltage transmission system would be reduced from current 6% down to 3.8%.
3. Total auxiliary needs of power plants from current 6.8% to 5.8% will decrease after the decommissioning of the ANPP.

PA

Table A.6. Forecasts of Total Generation by Growth Scenarios

Year	Net Export (mln kWh)	Medium			High			Low		
		Total Dome-stic Needs (mln kWh)	Net Gene-ration (mln kWh)	Gross Gene-ration (mln kWh)	Total Dome-stic Needs (mln kWh)	Net Gene-ration (mln kWh)	Gross Gene-ration (mln kWh)	Total Dome-stic Needs (mln kWh)	Net Gene-ration (mln kWh)	Gross Gene-ration (mln kWh)
2002	377	4490	5240	5623	4490	5240	5623	4490	5240	5623
2003	348	4181	4868	5223	4421	5122	5496	3587	4237	4546
2004	288	4229	4842	5196	5161	5830	6255	3734	4318	4633
2005	370	4264	4954	5315	5229	5974	6409	3762	4424	4746
2006	262	4299	4870	5225	5486	6122	6568	3789	4333	4649
2007	369	4335	5005	5370	5558	6291	6750	3817	4460	4786
2008	356	4371	5017	5383	5631	6338	6801	3846	4465	4791
2009	298	4408	4983	5346	5704	6338	6801	3875	4424	4747
2010	380	4446	5096	5467	5778	6487	6960	3904	4529	4860
2011	273	4484	5015	5381	5852	6440	6910	3933	4441	4765
2012	380	4523	5152	5527	5929	6613	7095	3967	4573	4907
2013	367	4562	5179	5557	6005	6678	7166	3999	4593	4928
2014	309	4602	5160	5536	6083	6699	7188	4032	4568	4901
2015	342	4642	5226	5548	6247	6894	7319	4066	4627	4912
2016	344	4683	5272	5596	6329	6983	7412	4100	4665	4953
2017	347	4724	5317	5645	6412	7072	7507	4133	4703	4992
2018	349	4766	5363	5694	6496	7162	7603	4167	4741	5033
2019	352	4809	5411	5744	6581	7253	7699	4202	4780	5074
2020	355	4852	5458	5794	6668	7346	7798	4237	4819	5116
2021	357	4896	5506	5845	6752	7436	7894	4272	4858	5157
2022	360	4941	5556	5898	6836	7526	7989	4308	4898	5200

Attachment to Appendix A

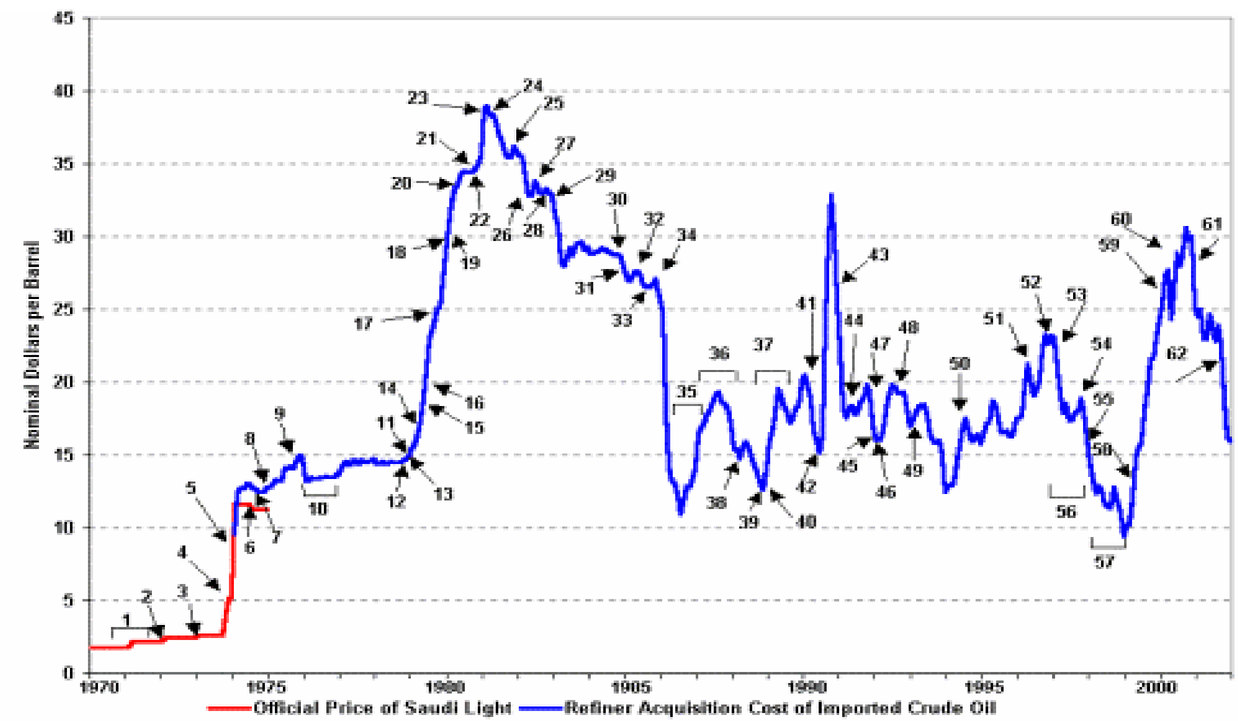
Net Load Forecast

World Oil Prices

Table B.1. Current Oil Prices

	Petroleum	Price ($/bbl)[1]	Change	Price, $/liter
▼	Nymex Crude	29.57	-0.04	0.26
▼	IPE Crude	28.3	-0.07	0.24
▼	Dated Brent $	28.32	-0.04	0.24
▼	WTI Cushing $	29.6	-0.01	0.26
▼	Nymex Heating oil	78.35	-0.04	0.68
▲	Nymex Gasoline	78.8	0.17	0.68

Figure B.1. Historical Oil Prices[2]



[1] As of Sep. 20, 2002, source: www.bloomberg.com
[2] Source: Energy Information Administration (EIA)

Table B.2. Forecast of future oil prices[3]

	WOP, $/bbl*	WOP, $/liter
2000	27.72	0.17
2001	22.48	0.14
2002	22.59074	0.14
2003	22.70203	0.14
2004	22.81386	0.14
2005	22.92624381	0.14
2006	23.03918	0.14
2007	23.15268	0.15
2008	23.26673	0.15
2009	23.38135	0.15
2010	23.49653	0.15
2011	23.61227	0.15
2012	23.72859	0.15
2013	23.84548	0.15
2014	23.96295	0.15
2015	24.08099	0.15
2016	24.19962	0.15
2017	24.31883	0.15
2018	24.43863	0.15
2019	24.55902	0.15
2020	24.68	0.16
2021**	24.80	0.16
2022**	28.67	0.18
2023**	33.84	0.21

Natural Gas
For the forecast of the future border gas prices please refer to the Attachment 1.

[3] Source: Energy Information Administration (EIA)

Table B.3. Current price structure for natural gas in Armenia

	Gas Price Structure			
	Price for large consumers, annual use>10,000cm		Price for other consumers, annual use<10,000cm	
	$	%	$	%
Price at border	53.0	67	53.0	57
Operating expenses	8.6	11	20.0	22
Technical losses	3.0	4	3.0	3
of which, transportation	1.8	2	1.8	2
of which, distribution	1.3	2	1.3	1
ArmRosGasProm margin	1.2	2	1.2	1
Sales price, w/o VAT	65.9	83	77.3	83
VAT	13.2	17	15.5	17
Consumer sales price	79.1	100	92.7	100

Table B.4. Historical Gas Prices for Power Plant in Armenia

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
$/1000 c.m.	7	18	49	54	62	75	79.1	79.1	79.1	79.1

Table B.5. Current World gas price

BLOOMBERG® Energy Price Chart World Gas Prices[4]		Price ($/MMBtu)	Change	Price, ($/1000cm)
▲	Nymex Henry Hub	3.29	0.03	104.4
	Henry Hub $	3.39	--	107.6
	Chicago City Gate $	3.39	--	107.6

[4] Source: www.bloomberg.com

Table B.6. Forecast of future World gas prices[5]

Natural gas, Average wellhead price

	Natural gas, $/cubic feet	Natural gas, $/1000c.m.[6]
2001	3.94	139.14
2002	1.98	69.92
2003	2.37	83.70
2004	2.58	91.11
2005	2.66	93.94
2006	2.70	95.35
2007	2.71	95.70
2008	2.79	98.53
2009	2.81	99.23
2010	2.85	100.65
2011	2.91	102.77
2012	2.97	104.88
2013	3.01	106.30
2014	3.03	107.00
2015	3.07	108.42
2016	3.09	109.12
2017	3.13	110.53
2018	3.17	111.95
2019	3.20	113.01
2020	3.26	115.13
2021[7]	3.32	117.28
2022[8]	3.32	117.28
2023[9]	3.32	117.28

Table B.7. Mazut at Power Plant

	1992	1993	1994	1995	1996	1997
$/tonne		46	58	83	113	135

Since 1997 mazut imports into Armenia have been very irregular. The fuel market, for the exception of gas and nuclear fuel, has been completely liberalized. State bodies, coordinating import of these products (Hard Oil Committee, Fuel committee, etc.) have been liquidated. All commercial importers of mazut contacted for this study stated that they have stopped importing mazut and are currently importing diesel oil and petroleum.

5 Source: Energy Information Administration (EIA)
6 Cubic feet /1000 c.m. conversion coefficient - 0.02831685
7 Own estimation, assuming the annual growth rate of 2020 continues to 2003
8 Same as in 6
9 Same as in 6

As the domestic delivered mazut, prices have exceeded the world delivered mazut prices since 1997, and they have caused almost 100% substitution of mazut by other fuel types, it can be assumed that the delivered mazut price will not be more than the 1997 price, in real terms. Therefore, to arrive to the 2003 price, the 1997 prices, after adjustment of off-loading and transportation expenses, were increased by 2.3% annual inflation (estimated end of period annual inflation for 2002[10]).

Table B.8. Price structure for Mazut at power plant, $/tonne

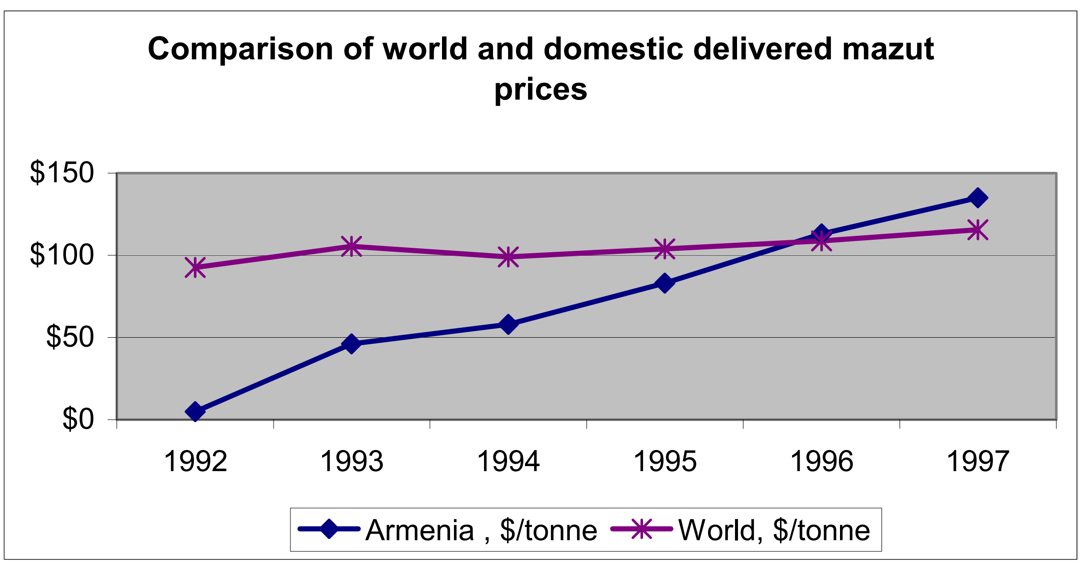
	1997	2003
Purchase price per tonne	$75	$75
Loading on the tanker ship	$3	$3
Shipping	$18	$18
Off-loading	$3	$3.4
Transport to Yerevan	$30-35	$34-40
Delivered price per tonne	**$ 129 - $ 134**	**$ 133.8 - $ 139.6**

For LCP, the average 2003 estimate, $136.5/tonne is used.

Table B.9. Comparison of world and domestic delivered mazut prices

	1992	1993	1994	1995	1996	1997
Armenia , $/tonne	$ 4.79	$ 46.20	$ 58.00	$ 83.15	$ 113.10	$ 135.00
Change, %	-	865%	26%	43%	36%	19%
World, $/tonne	$ 92.54	$ 105.40	$ 99.10	$ 103.90	$ 108.76	$ 115.54
Change, %		14%	-6%	5%	5%	6%

Figure B.2. Comparison of World and Domestic Delivered Mazut Prices



[10] Source: Central Bank of Armenia

Financial costs of maintaining 10-days’ inventory of mazut

Based on Yerevan TPP and Hrazdan TPP generations, taking into account the seasonality of generation, assuming 20% bank interest rate, we can calculate the following:

Table B.10

	Generation per month, MW/h		Generation per day, MW/h		Mazut consumption tonne/day		Mazut consumption, tonne/year		Cost, $	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Yerevan TPP	40	50	1.3	1.7	3.3	4.2	1,217	1,521	166,075	207,594
Hrazdan TPP	200	400	6.7	13.3	16.7	33.3	6,083	12,167	830,375	1,660,750
Total	**240**	**450**	**8**	**15**	**20**	**37.5**	**7,300**	**13,688**	**996,450**	**1,868,344**

Table B.11

	10-days' inventory, tonnes		10-days' inventory cost		Working capital cost of 10-days' inventory	
	Min	Max	Min	Max	Min	Max
Yerevan TPP	13.3	16.7	$ 1,820	$ 2,275	$ 364	$ 455
Hrazdan TPP	66.7	133.3	$ 9,100	$ 18,200	$ 1,820	$ 3,640
Total	**80.0**	**150.0**	**$ 10,920**	**$ 20,475**	**$ 2,184**	**$ 4,095**

10-days’ inventory of mazut, therefore, will cost $10,920 in the summer and $20,475 in the winter. At the 20% bank interest rates, the financial cost of maintaining 10-days’ inventory of mazut will be: $2,184 in the summer and $4,095 in the winter. Now the calculation price of mazut was completed by adjusting for the financial costs of maintaining 10-days’ inventory, as presented below. Financial costs associated with inventory weight 0.2% in overall price and comprise $0.3 per tonne.

Table B.12

	Min, $	Max, $
Cost of mazut, annual basis	996,450	1,868,344
Fin cost of maintaining 10-days' inventory	2,184	4,095
Cost of mazut, including fin. costs annual basis	998,634	1,872,439
Price of Mazut including Fin. Costs	**136.8**	**136.8**

Table B.13. Coal

Years	Coal Source	Quantity (tonnes)	Moisture (%)	Ash Content (%)	Calorific Value (Kcal/Kg)	Cost /tonne ($)
1992	Rostovugol, Russia	44,902	3.6	10.0	8,300	
		28,308	4.02	12.6	7,500	
	Tkibuli, Georgia	879	16.0	37.0	3.600	
1993	Tkibuli, Georgia	1,360	16.0	37.0	3,600	43.55
	Idjevan, Armenia	8,500	16.6	36.8	5,900	91.94
	Djadjur, Armenia	5.450	23.5	24.0	3,880	
1994	Rostovugol. Russia	2,625	3.6	10.0	8,300	72.9-110.5
	Kemerov, Russia	3,152	2.9	40.3	6,100	41.96
	Tkibuli, Georgia	740	8.0	30.5	4,900	37.50
		1,032	16.0	37.0	3,600	
	Idjevan, Armenia	110	12.5	15.6	6,300	
		130	8.3	44.0	2,700	37.90
1995	Kemerov, Russia	1,935	2.18	35.0	4,500	42.00
	Tkibuli, Georgia	740	8.0	30.5	4,900	74.10
	Rostovugol, Russia	617	0.6	36.8	5,000	111.12
	Djadjur. Armenia	30	2.71	14.63	5,100	
	Idjevan. Armenia	60	8.3	44.0	2,700	
1996	Tkibuli, Georgia	2,000	8.0	30.5	4.900	72.64
	Idjevan, Armenia	100	8.3	44.0	2,700	

Table B.14. Current price structure for coal

	Anthracite ($tonne)	Bituminous ($ tonne)
Cost at mine (Rostov)	70-75	30-40
Transportation to	70-75	70-75
Final cost	140-150	100-115

Nuclear fuel

Historic information on nuclear fuel is not available. Current price is 0.6 c/KWh (VAT exempt) at Metsamor NPP.

References:

1. ***Fuel Supply Report*** – 1999 Update, Hagler Bailly, Merklein and Associate, 1999
2. "***Results from the OECD Report on International Projections of Electricity Generating Costs***", Proceedings of IJPGC 98, 24-26 August 1998, Baltimore, MD.
3. ***Quantitative Assessment of Trends in Armenia Energy Sector up to Year 2010***, ERC, 1999
4. ***The Nor Arevik Coal Deposit, Southern Armenia***, Draft Report, USGS, 1999
5. ***Potential Minability and Economic Viability of the Antaramut-Kurtan-Dzoragukh***, Pre-Feasibility Study, USGS, 1999
6. ***Armenia: Power Supply/Conservation Program***, CFB Unit at Hrazdan TPP, Feasibility Study, Burns and Roe, 1998
7. ***Annual Energy Outlook 2002: Energy Information Administration***

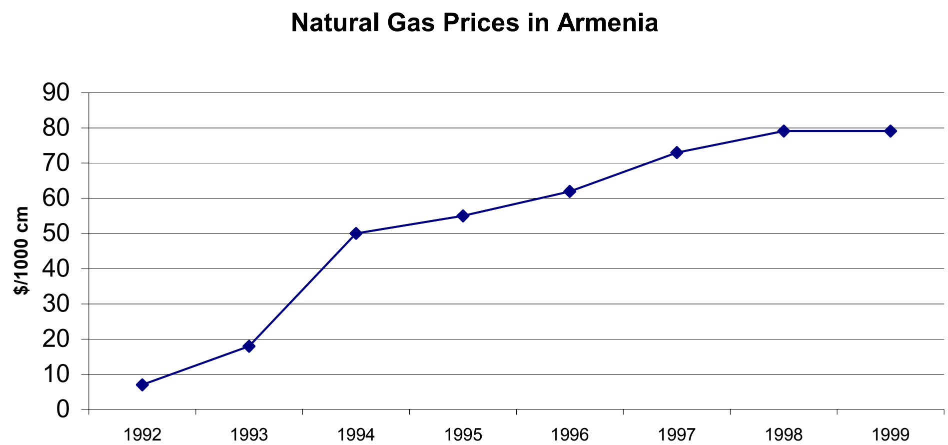
Attachment 1

1. Forecast of the border gas price for Armenia

1.1 Background

The historical prices of gas charged to the power stations are presented in the Figure B.3.

Figure B.3. Natural Gas Prices in Armenia



As the above chart suggests, the historical data are not indicative of future gas prices. Given the magnitude of factors affecting the imported gas price, the world trend of the gas prices is not fully applicable for the LCP purposes, either. The excessive increases in the gas prices in Armenia since 1992 reflect the liberalization of gas export prices both in Russia and Turkmenistan and their gradual increase towards world gas prices.

Therefore, in forecasting future gas prices, an emphasis should be placed on the analysis of qualitative factors influencing gas prices rather than applying pure quantitative methods, such as trend analysis and regression. To best reflect the qualitative factors, scenario analysis framework is adopted where each scenario is constructed on the basis of assumptions about certain factors, mentioned above.

The political and other factors are analyzed separately in this forecast.

1.1.1 Political considerations

Political considerations still play an important role in pricing the gas exports by Russia. This could be clearly observed by studying Russian gas export prices and payment mechanisms for different countries (see the table B.15 below).

Table B.15. Russian gas export prices and payment mechanisms

	Border Price, $/1000c.m.	Major Payment Mechanisms
Belarus	30	Clearing
Armenia	53	Clearing and 50% barter
Ukraine	55	Clearing
Georgia	60	Cash; Advance payments
Moldova	60-80	Clearing
Baltic states	80-90	Cash
Western Europe	80-100	Cash

The border price for gas is formed in result of two components: export price and transit fare. Transit fare is usually paid in gas by the supplier. In case of Armenia, the transfer fee component is estimated $8 per 1000c.m.[11]. In 2001, the border price structure was the following:

Export price	45
Transit fare	8
Total	53

The $45 per 1000 c.m. appears to be the politically neutral export price for Russia. Since Russia and Turkmenistan compete closely for the Armenian gas market, the differences in Russian and Turkmenistani gas prices tend to be negligible. Therefore, the above statement is true for all gas imports by Armenia. In fact, Itera Corp. has suggested a $45 per 1000c.m. price for Armenia if Armenia pays in advance cash payments. Although the situation with Itera Corp. is complicated with the asset swap agreements, this is also an indication of the lowest Armenian import price.

1.1.2 Other factors

Apart from political considerations, the following factors are also considered to determine the border gas prices for Armenia:

- Competition between major suppliers, i.e. Russia and Turkmenistan;
- Differences in the world and Russian export prices for gas;
- Requirements of international organizations;
- Marginal substitution effects and the risk of decrease of export volumes to Armenia and CIS countries in general due to high sensitivity to gas prices, which is the result of low purchasing power ; and,
- High default risk in Armenia and CIS countries in general.

[11] *Identification of priority investments of the gas sector in accordance with the RA strategy of urban heating*, 2002, Government of Armenia, the World Bank

The first two factors imply that sharp increases in gas prices are unlikely. Also, in case of an increase, Russia and Turkmenistan will adjust their prices quickly. The third factor, in its turn, implies that the suppliers are likely to charge a premium for existing risks, unless payment patterns improve or payments are made in cash.

Current border gas price for Armenia is set by a contract between Itera Corp. and ArmRusGazArd and is subject of annual revision. The last revision took place in 2002 when the price for 1000 c.m. increased from $53 to current $55.

Despite the seeming independence of Itera Corp. in setting the border gas prices, the export prices are, in fact, greatly influenced by the Russian state. Gazprom, which is 100% state-owned enterprise, has let Itera Corp. take over the export markets of CIS, because:

- It creates visibility of competition in Russian gas exports. Competition in gas export sector has been demanded by the IMF.
- Itera Corp. is formally free from political considerations and supplies gas on contractual and “free-market” basis, which is more appropriate in the markets of CIS which have high non-payment risks.

Scenario 1: Compromise Estimate of the International Organizations (Int. Org. Estimate)

A World Bank sponsored study, ***Identification of priority investments of the gas sector in accordance with the RA strategy of urban heating***, forecasts gas prices in three scenarios, where the Armenian border price reaches the world gas prices in 2010, 2015 and 2020, accordingly. These assumptions translate into average geometric annual growth rates of 2.3%, 2.6% and 3.5%, correspondingly.

Some OECD and IEA publications (see reference) have estimated annual growth rates for natural gas prices both for OECD and Non-OECD countries (including Russia). They vary from 0.1%-0.2%/year in Brazil and Hungary to 2.7%-3.8%/year in Japan and the US. Current pricing of natural gas also varies significantly. The Russian gas price in year 2005 is predicted to be about $2.68/GJ, which corresponds to growth of approximately 2.4 percent per year.

Therefore a **consensus 2.5% escalation factor** was used for this scenario. This rate reflects both international estimates and the expectations of reaching the world gas prices by 2015.

Scenario 2: Equivalent Western European Price (West. Eur. Equivalent)

For this scenario, it was assumed that in 2010 Russian gas export prices for Armenia will reach that of the Western Europe ($80 in 2002). An annual 0.2% increase in Russian export prices to the Western Europe is incorporated into the scenario, using the OECD and IEA estimate of gas price growth rates for Russia. This corresponds to **5% annual growth rate** until 2010, when the border price equals that of Western Europe, and **0.2% annual growth rate** after 2010.

Scenario 3: Growth at the Russian Gas PPI (Russian Gas PPI)

In forecasting the price of gas, another factor to take into account in the forecast of the prices for Russian gas exports is the producers price index (PPI) for Russian gas industry. Refer to the appendices for the historical PPI.

PPI for gas has been affected by sharp increases in June 2001 (39.4%) and January 2002 (15.1%). These shocks (in terms of statistics) reflect the policy of Russia to increase the domestic gas rates. These increases have been carried out under the pressure of WTO, which requires Russia to raise its domestic gas rates up to 3 times. Therefore, these increases have no relationship to the Russian gas export prices and should be neutralized.

If the effects of these increases are excluded, an 8.4% average annual growth rate of PPI is derived for Russian gas industry in 2001. After adjustments for the 7% devaluation of Russian ruble, a 1.4% annual growth in PPI is derived in dollar terms in 2001. In the second half of 2002, Russia has systematically increased its domestic gas rates which has resulted in 19.1% increase in PPI for gas industry (a 16.1% increase in US dollar terms.) Therefore, there is no account of the developments in the 1st half for the purpose of our calculations.

We will use **1.4% annual growth** rate for this scenario.

The resulting scenarios are presented below.

APPENDIX C: RESULTS OF DETAILED ANALYSIS

The 2002 LCP results are based on scenario analysis. Ten scenarios were analyzed and shown below in summary form.

CASE 1. BASE CASE/SCENARIO
ANPP Retirement in 2009 / Medium Demand / WACC / Fuel Price Forecasts
CASE 2. ALTERNATIVE SCENARIO
ANPP Retirement in 2015 /Medium Demand / WACC / Fuel Price Forecasts
CASE 3. HIGH DEMAND FORECAST
ANPP Retirement in 2009 / Medium WACC / Fuel Price / High Demand Forecasts
CASE 4. LOW DEMAND FORECAST
ANPP Retirement in 2009/Medium WACC / Fuel Price/Low Demand Forecasts
CASE 5. HIGH FUEL PRICE FORECAST
ANPP Retirement in 2009/Medium WACC / Demand / High Fuel Price Forecasts
CASE 6. LOW FUEL PRICE FORECAST
ANPP Retirement in 2009/Medium WACC / Demand / Low Fuel Price Forecasts
CASE 7. HIGH DISCOUNT RATE FORECAST
ANPP Retirement in 2009 / Medium Demand / Fuel Price Forecasts/ High WACC Forecast
CASE 8. LOW DISCOUNT RATE FORECAST
ANPP Retirement in 2009 / Medium Demand / Fuel Price Forecasts/ Low WACC Forecast
CASE 9. 30% RESERVE MARGIN – RELIABILITY
ANPP Retirement in 2009 / Medium Demand / WACC / Fuel Price Forecasts / 30% Reserve requirement
CASE 10. MEGRI HPP ENFORCEMENT - STRATEGIC
ANPP Retirement in 2009 / Medium Demand / WACC / Fuel Price Forecasts /Meghri HPP Enforcement

CASE 1. BASE CASE

Table C.1. Capacity Additions and Retirements

Year	2003	2006	2007	2008	2009	2016
Gas Other			75 GTS	75 GTS	75 GTS	75 GTS
Nuclear					-346 ANPP Unit 2	
Gas CHP	-2*44 Yerevan CHP 2&4 -2*92 Hrazdan CHP 3&4	-46 Hrazdan CHP 2	-46 Hrazdan CHP 1			
Coal						
CombCycle						
Hydro						
Total	**-272**	**-46**	**29**	**75**	**-271**	**75**

Note: (+) – Additions
(-) – Retirements

Figure C.1. Energy Supply by Fuel Type

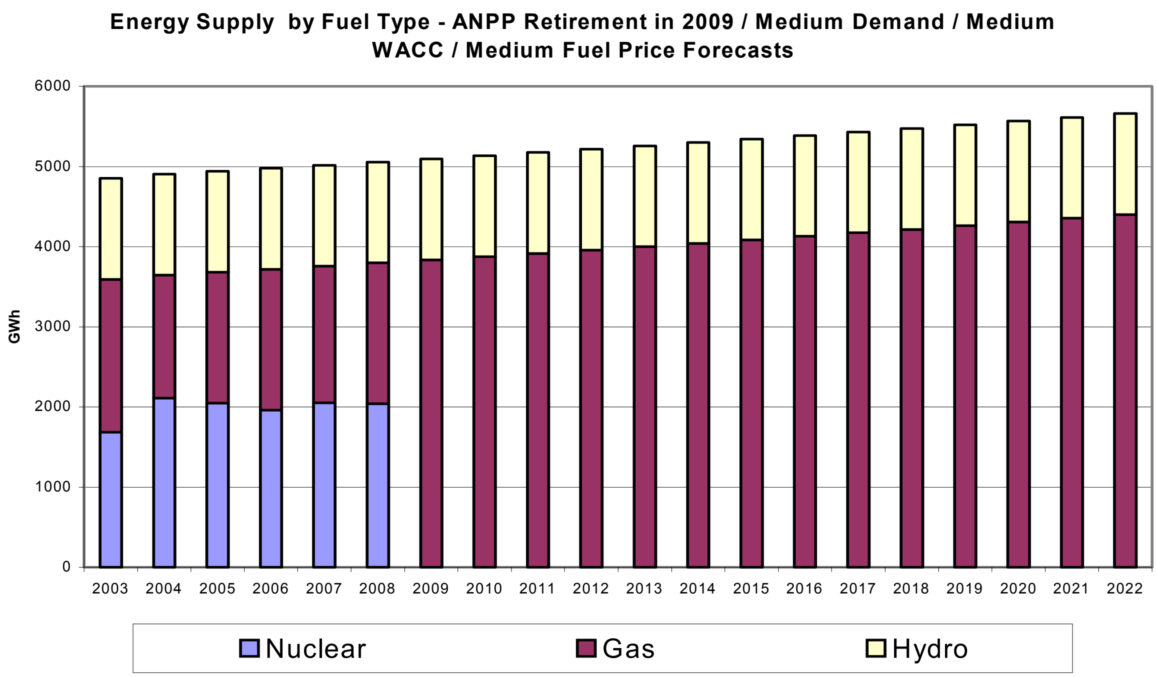


Figure C.2. Generating Capacity Mix by Fuel Type

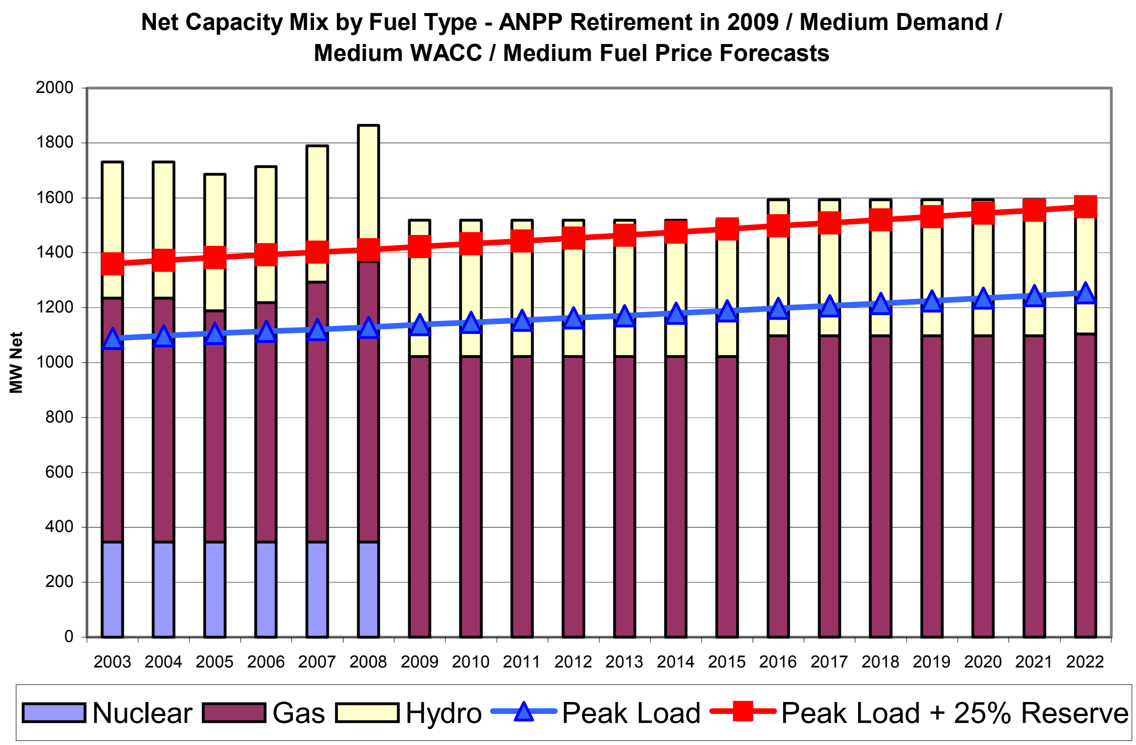
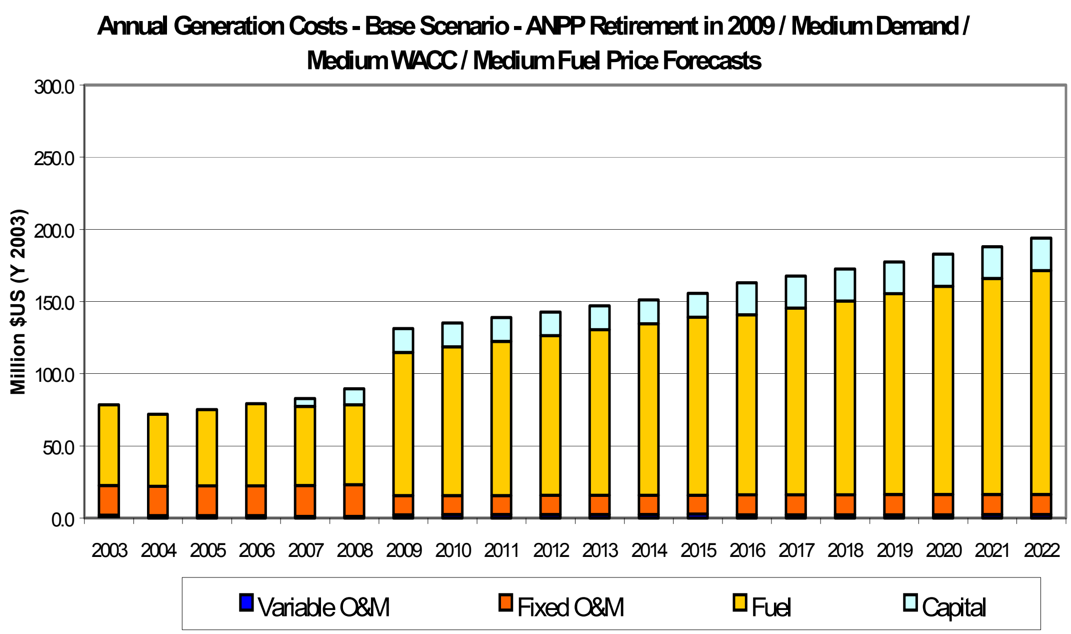


Figure C.3. Annual Costs ($2003) for Generation



CASE 2. ALTERNATIVE SCENARIO – ANPP RETIREMENT IN 2015

Table C.2. Capacity Additions and Retirements

Year	2003	2006	2007	2009	2014	2015	2016
Gas Other				75 GTS	75 GTS	75 GTS	75 GTS
Nuclear						-346 ANPP Unit 2	
Gas CHP	-2*44 Yerevan CHP 2&4 -2*92 Hrazdan CHP 3&4	-46 Hrazdan CHP 2	-46 Hrazdan CHP 1				
Coal							
CombCycle							
Hydro							
Total	**-272**	**-46**	**-46**	**75**	**75**	**-271**	**75**

Note: (+) – Additions
(-) – Retirements

Figure C.4. Generation Capacity Mix

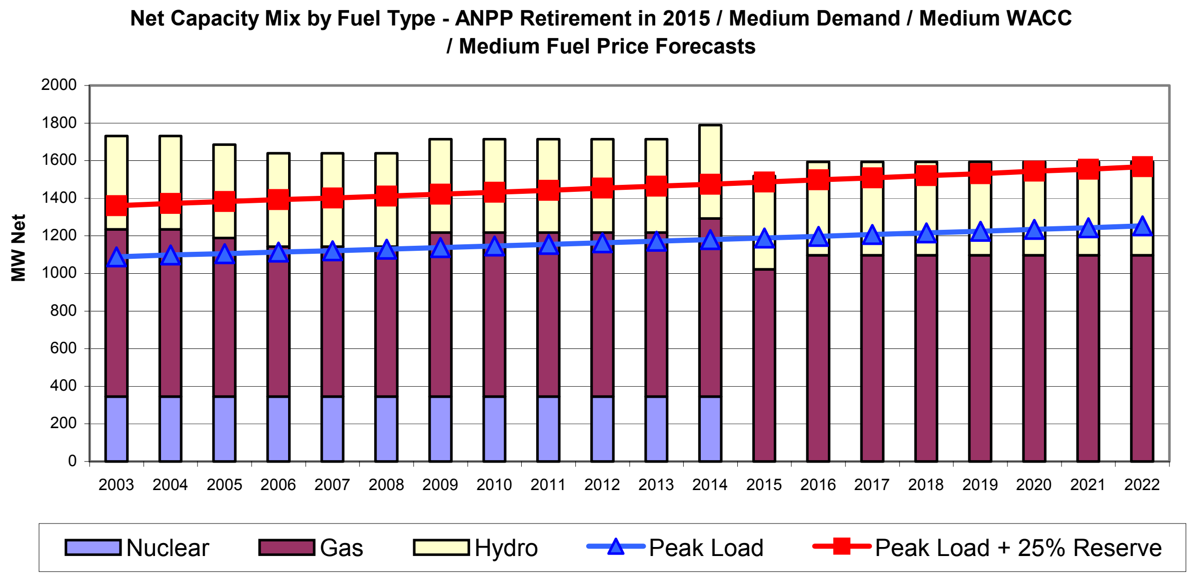


Figure C.5. Generation Energy Mix

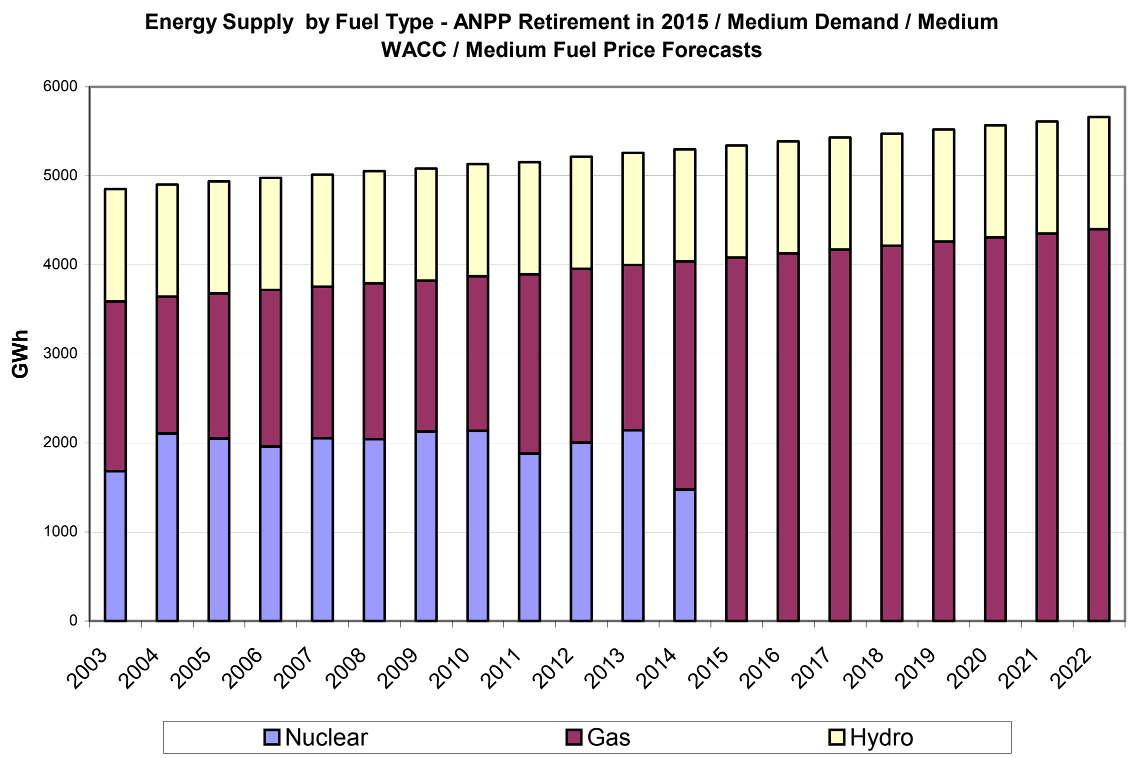
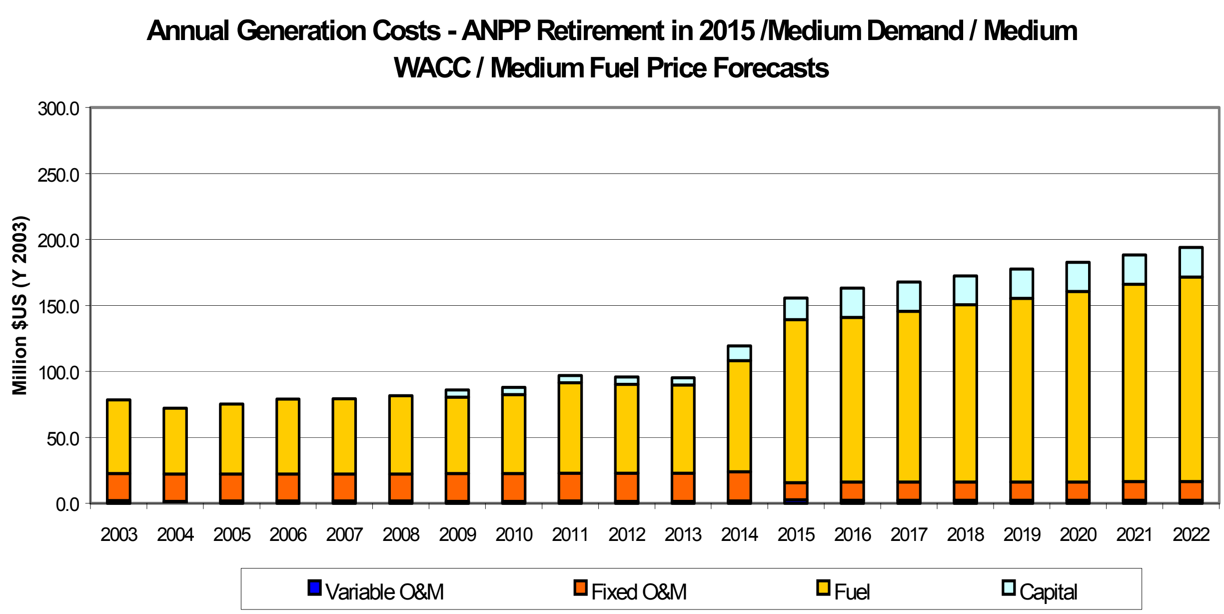


Figure C.6. Annual Generation Costs



CASE 3. HIGH DEMAND FORECAST

Table C.3. Capacity Additions and Retirements

Year	2003	2006	2007	2008	2009	2011	2014	2018	2022
Gas Other			75 GTS	75 GTS	3*75 GTS	75 GTS	75 GTS	75 GTS	75 GTS
Nuclear					-346 ANPP Unit 2				
Gas CHP	-2*44 Yerevan CHP 2 & 4 -2*92 Hrazdan CHP 3 & 4	-46 Hrazdan CHP 2	-46 Hrazdan CHP 1						
Coal									
CC									
Hydro									
Total	**-272**	**-46**	**29**	**75**	**-121**	**75**	**75**	**75**	**75**

Note: (+) – Additions
(-) – Retirements

Figure C.7. Generation Capacity Mix

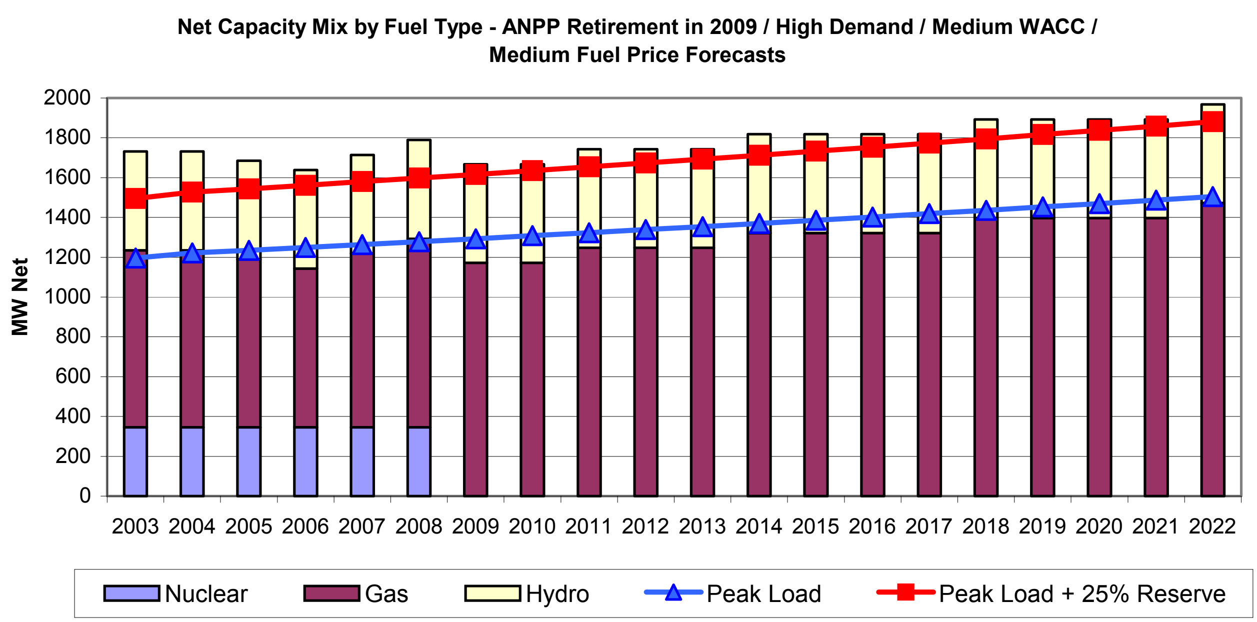


Figure C.8. Generation Energy Mix

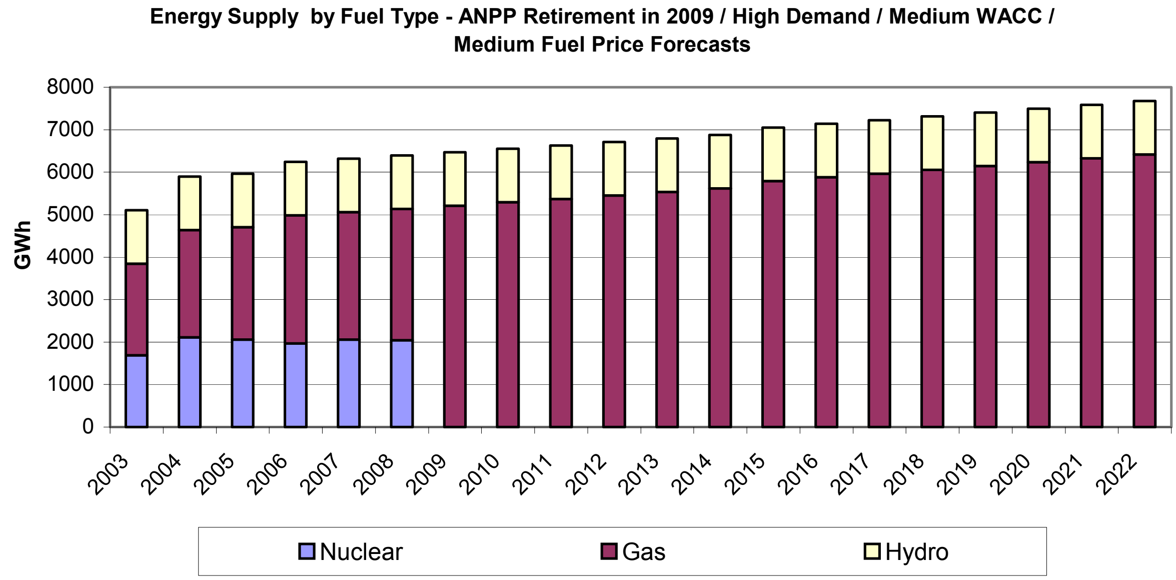
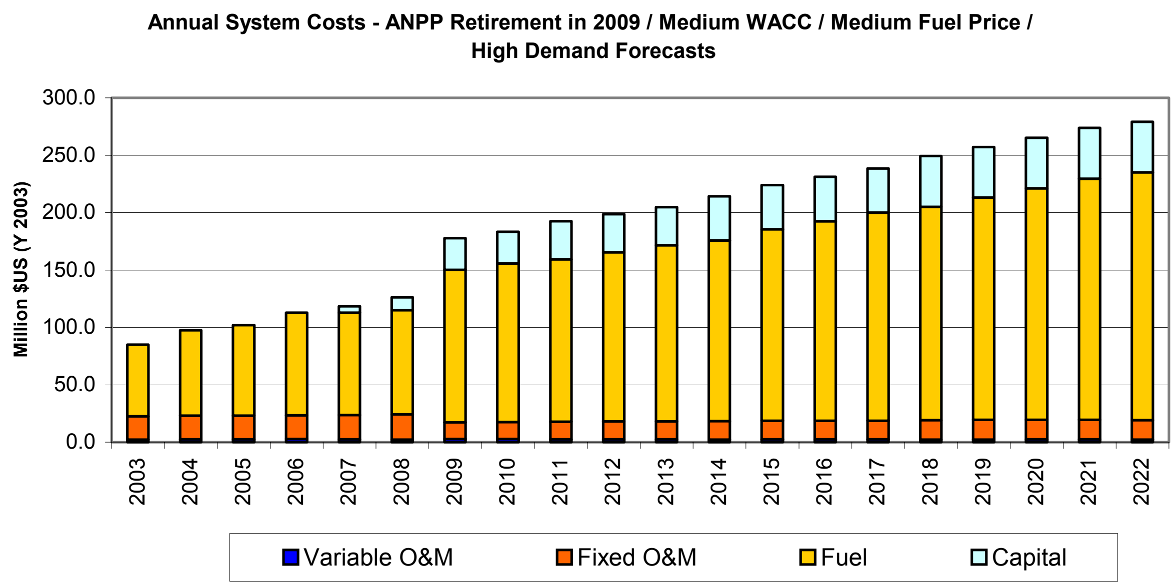


Figure C.9. Annual Generation Costs



CASE 4. LOW DEMAND FORECAST

Table C.4. Capacity Additions and Retirements

Year	2003	2006	2007	2009	2016
Gas Other				75 GTS	75 GTS
Nuclear				-346 ANPP Unit 2	
Gas CHP	-2*44 Yerevan CHP 2 & 4 -2*92 Hrazdan CHP 3 & 4	-46 Hrazdan CHP 2	-46 Hrazdan CHP 1		
Coal					
CC					
Hydro					
Total	**-272**	**-46**	**-46**	**-271**	**75**

Note: (+) – Additions
(-) – Retirements

Figure C.10. Generation Capacity Mix

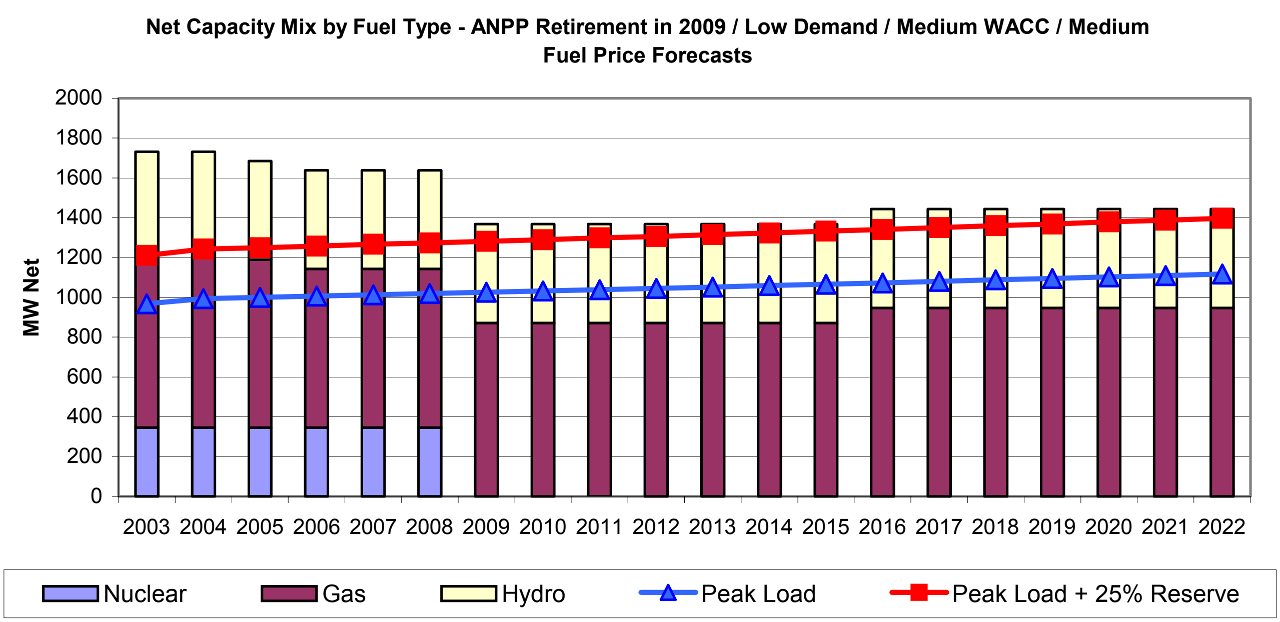


Figure C.11. Generation Energy Mix

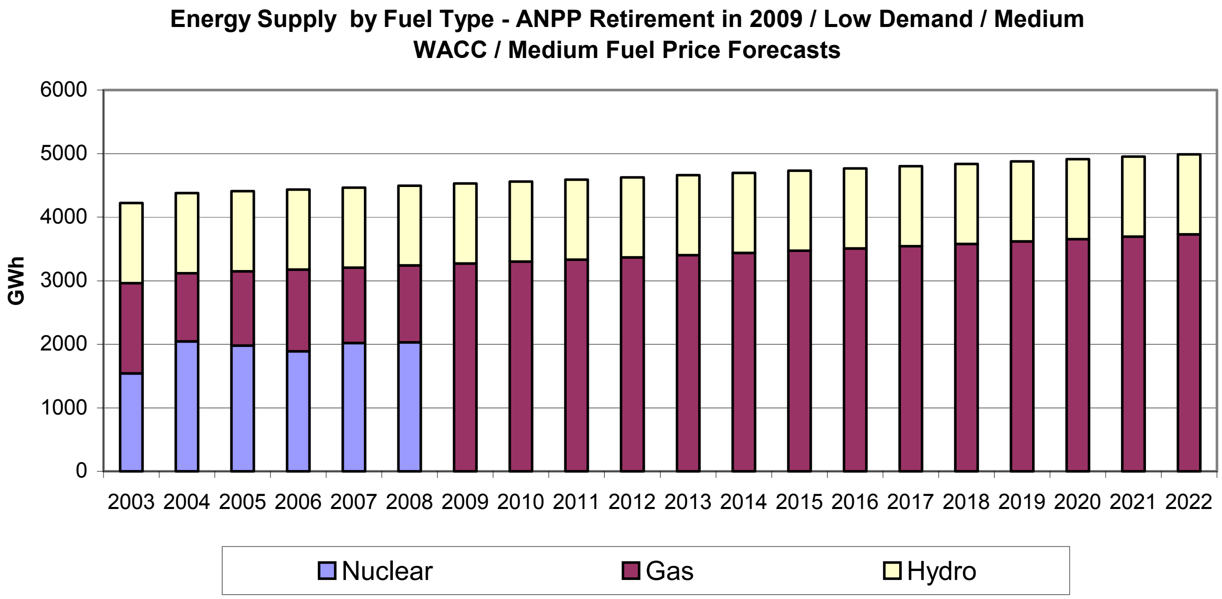
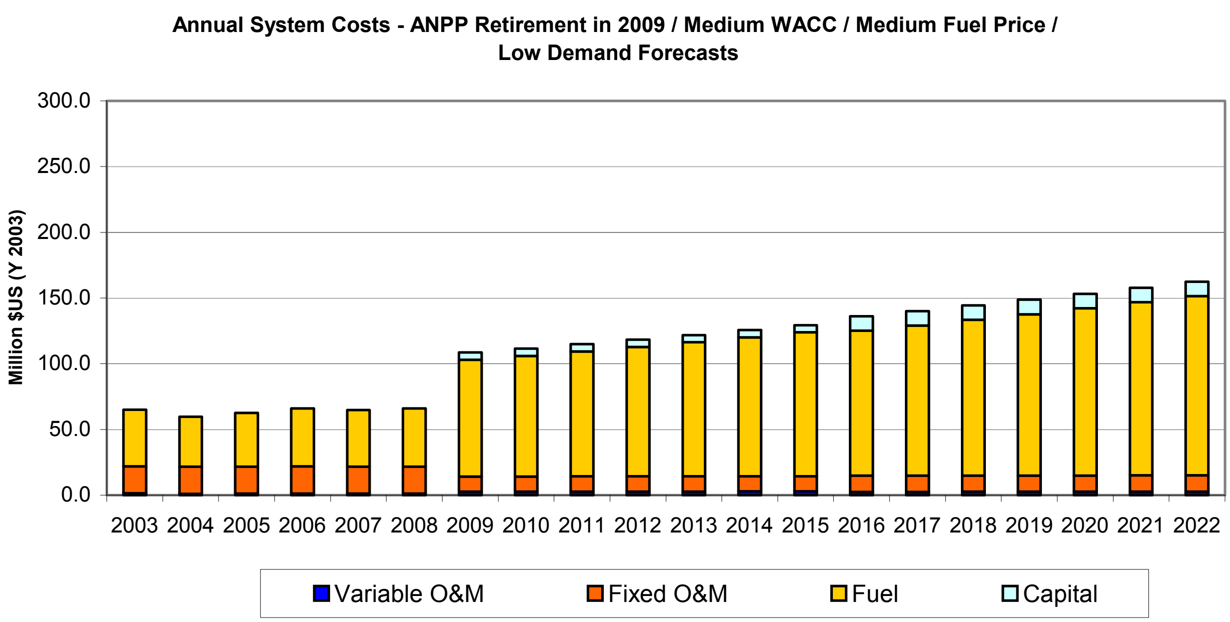


Figure C.12. Annual Generation Costs



CASE 5. HIGH FUEL PRICE FORECAST

Table C.5. Capacity Additions and Retirements

Year	2003	2006	2007	2008	2009	2016
Gas Other				75 GTS	2*75 GTS	75 GTS
Nuclear					-346 ANPP Unit 2	
Gas CHP	-2*44 Yerevan CHP 2 & 4 -2*92 Hrazdan CHP 3 & 4	-46 Hrazdan CHP 2	-46 Hrazdan CHP 1			
Coal						
CC						
Hydro						
Total	**-272**	**-46**	**-46**	**75**	**-196**	**75**

Note: (+) – Additions
(-) – Retirements

Figure C.13. Generation Capacity Mix

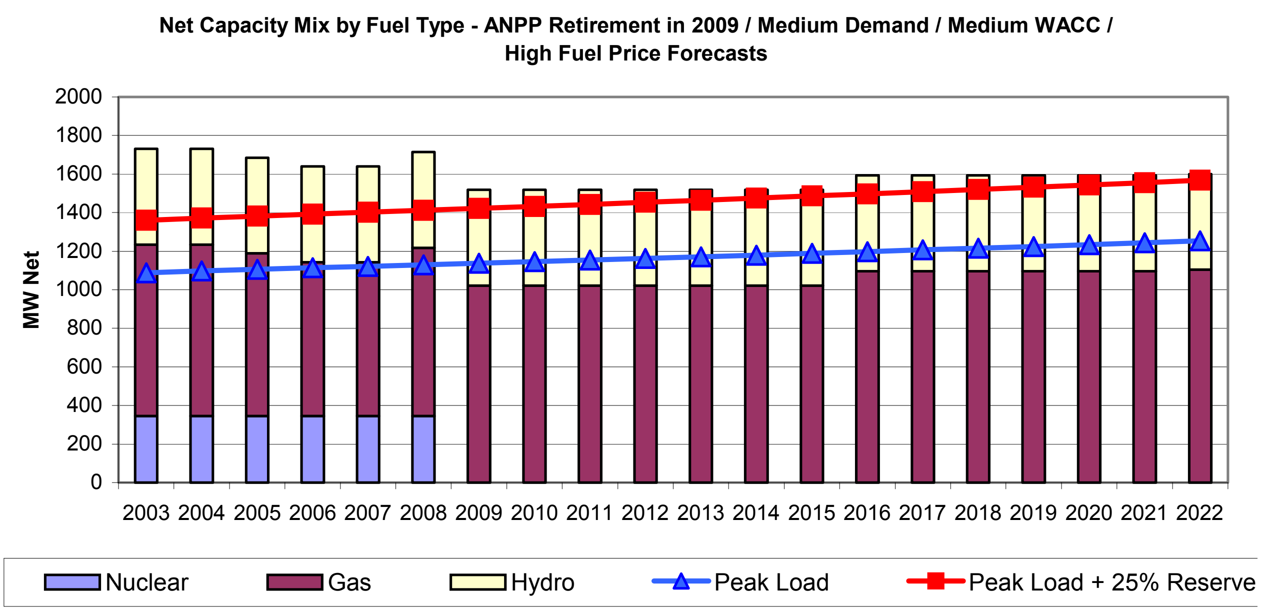


Figure C.14. Generation Energy Mix

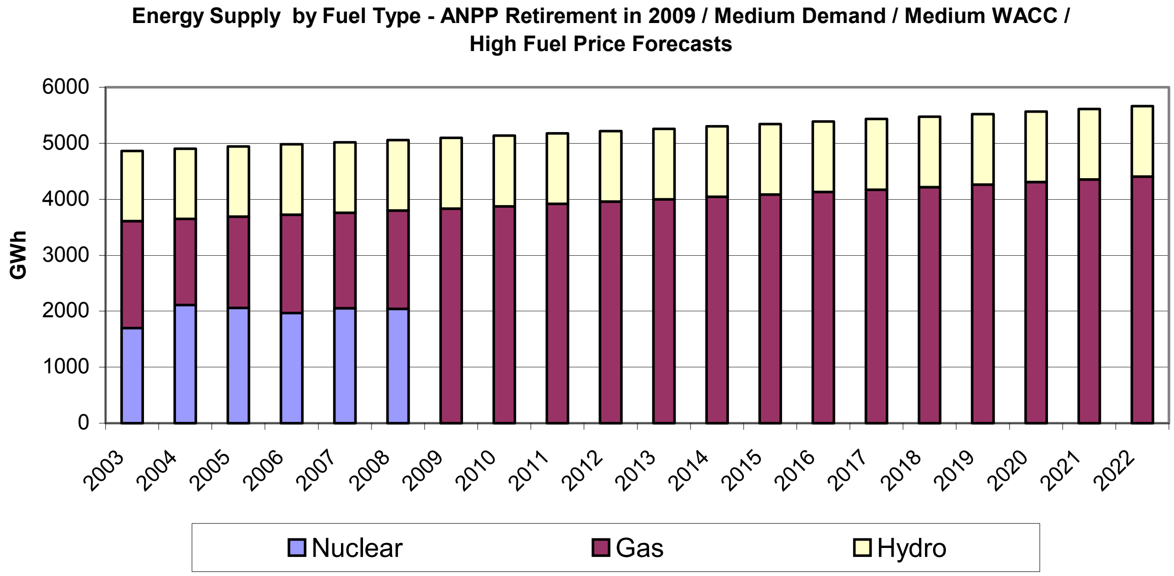
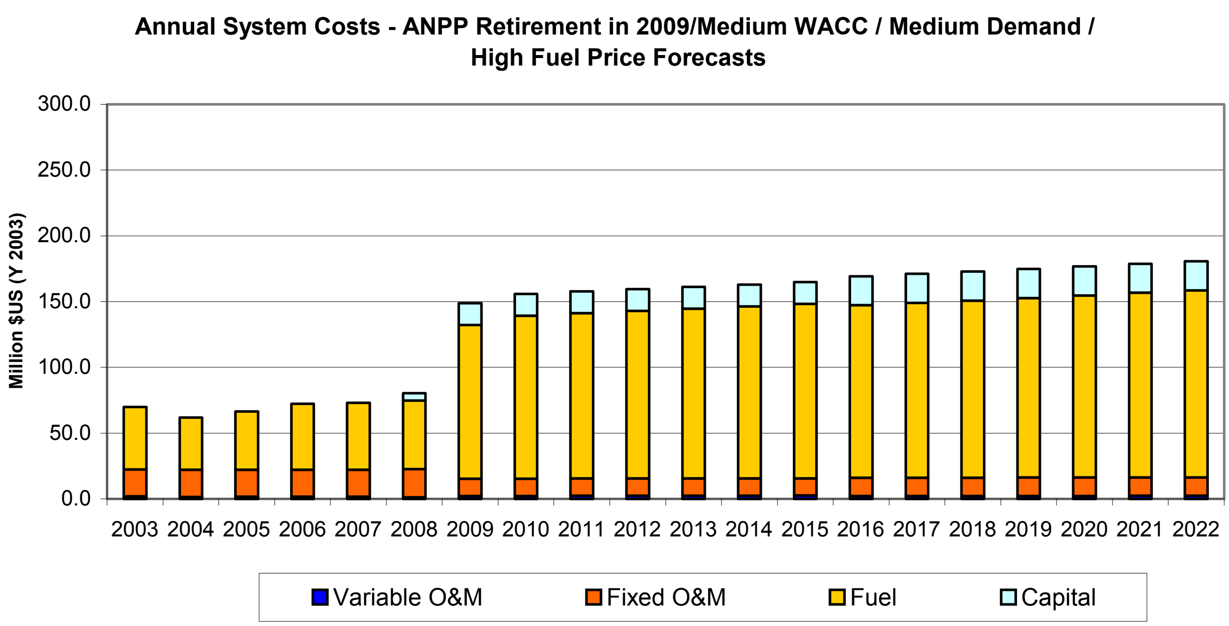


Figure C.15. Annual Generation Costs



CASE 6. LOW FUEL PRICE FORECAST

Table C.6. Capacity Additions and Retirements

Year	2003	2006	2007	2008	2009	2016
Gas Other				75 GTS	2*75 GTS	75 GTS
Nuclear					-346 ANPP Unit 2	
Gas CHP	-2*44 Yerevan CHP 2 & 4 -2*92 Hrazdan CHP 3 & 4	-46 Hrazdan CHP 2	-46 Hrazdan CHP 1			
Coal						
CC						
Hydro						
Total	**-272**	**-46**	**-46**	**75**	**-196**	**75**

Note: (+) – Additions
(-) – Retirements

Figure C.16. Generation Capacity Mix

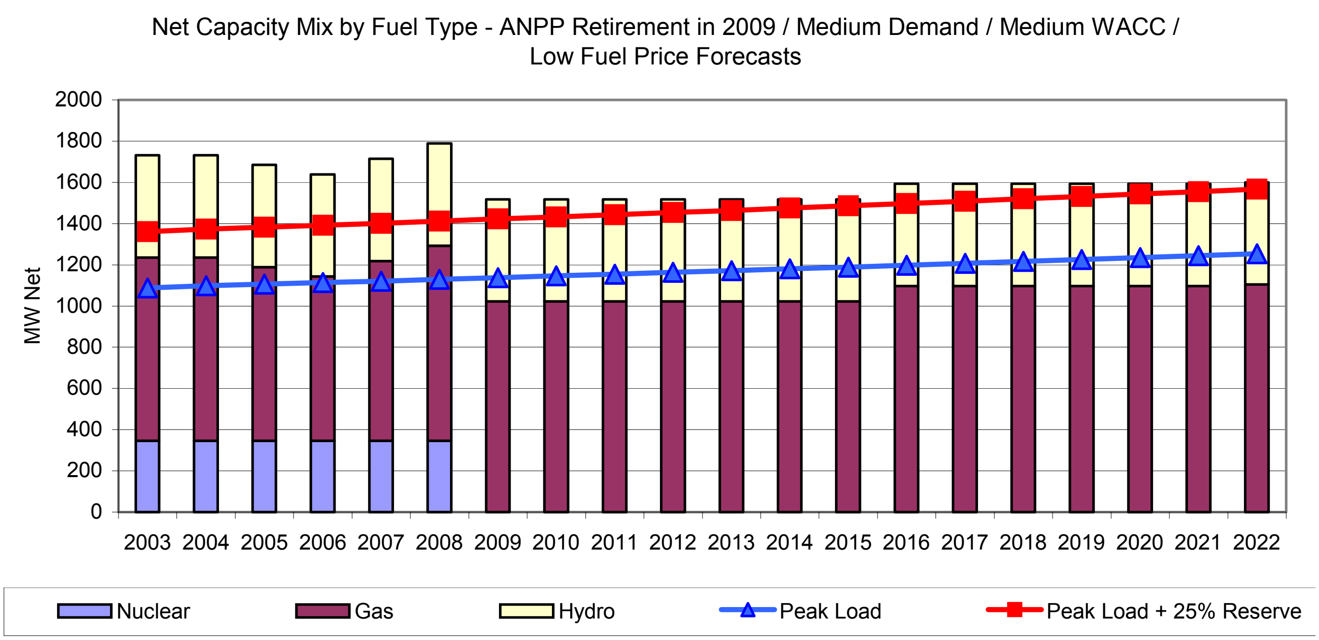


Figure C.17. Generation Energy Mix

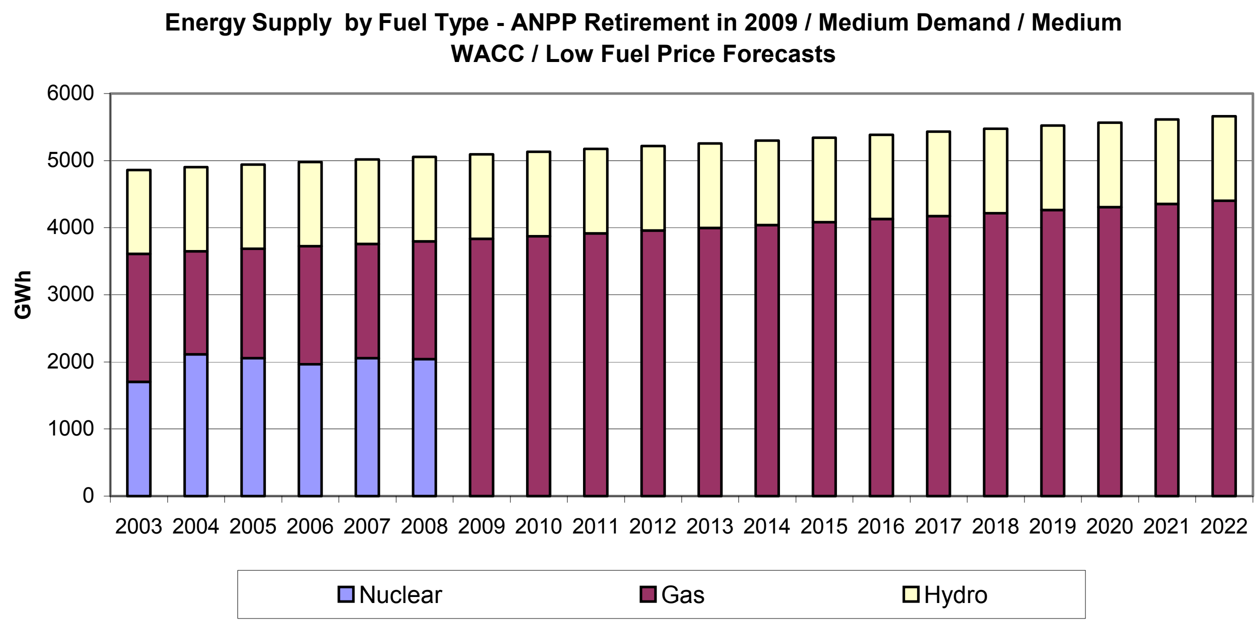
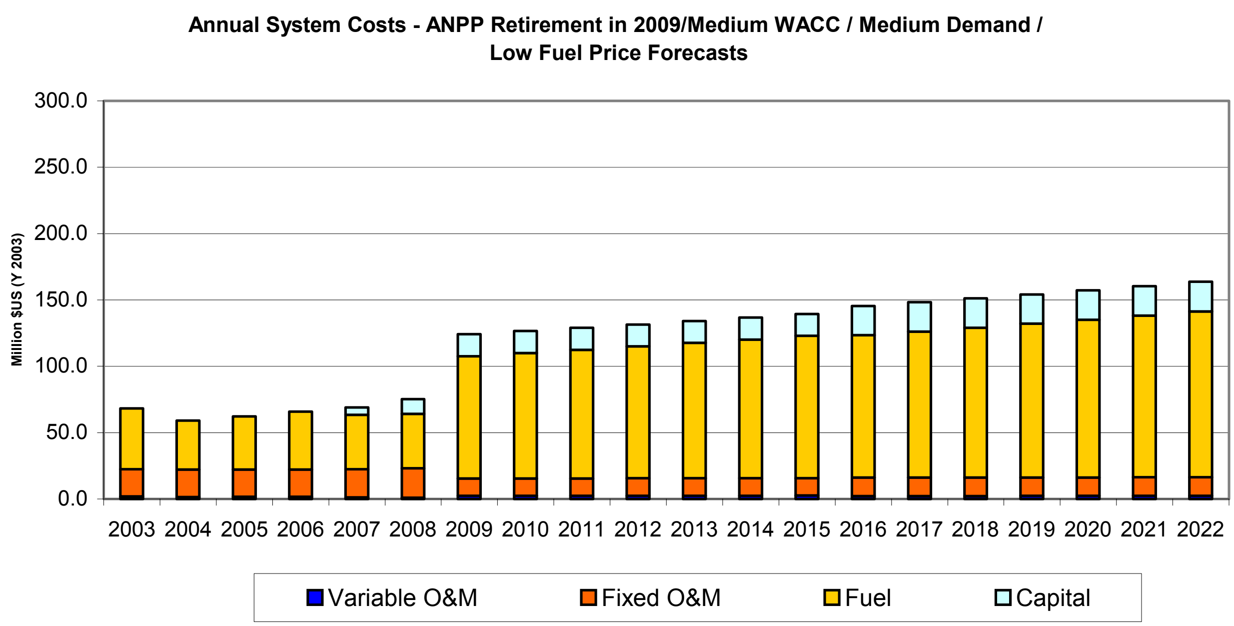


Figure C.18. Annual Generation Costs



CASE 7. HIGH DISCOUNT RATE FORECAST

Table C.7. Capacity Additions and Retirements

Year	2003	2006	2007	2009
Gas Other				400 CC
Nuclear				-346 ANPP Unit 2
Gas CHP	-2*44 Yerevan CHP 2 & 4 -2*92 Hrazdan CHP 3 & 4	-46 Hrazdan CHP 2	-46 Hrazdan CHP 1	
Coal				
CC				
Hydro				
Total	**-272**	**-46**	**-46**	**54**

Note: (+) – Additions
(-) – Retirements

Figure C.19. Generation Capacity Mix

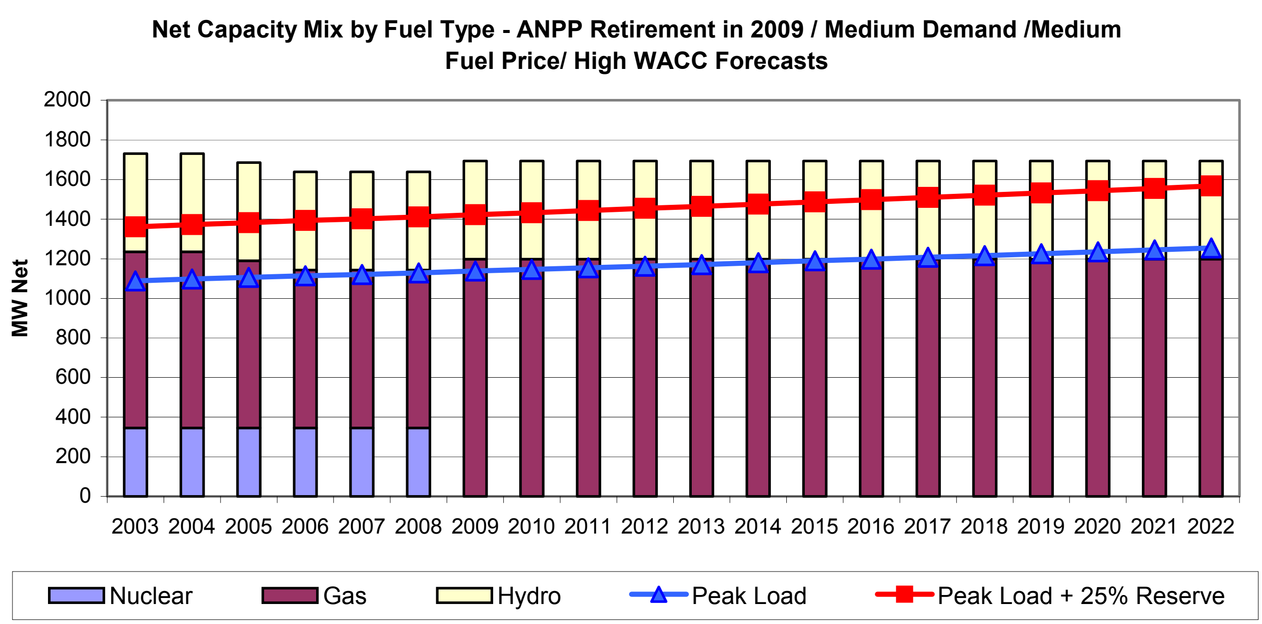


Figure C.20. Generation Energy Mix

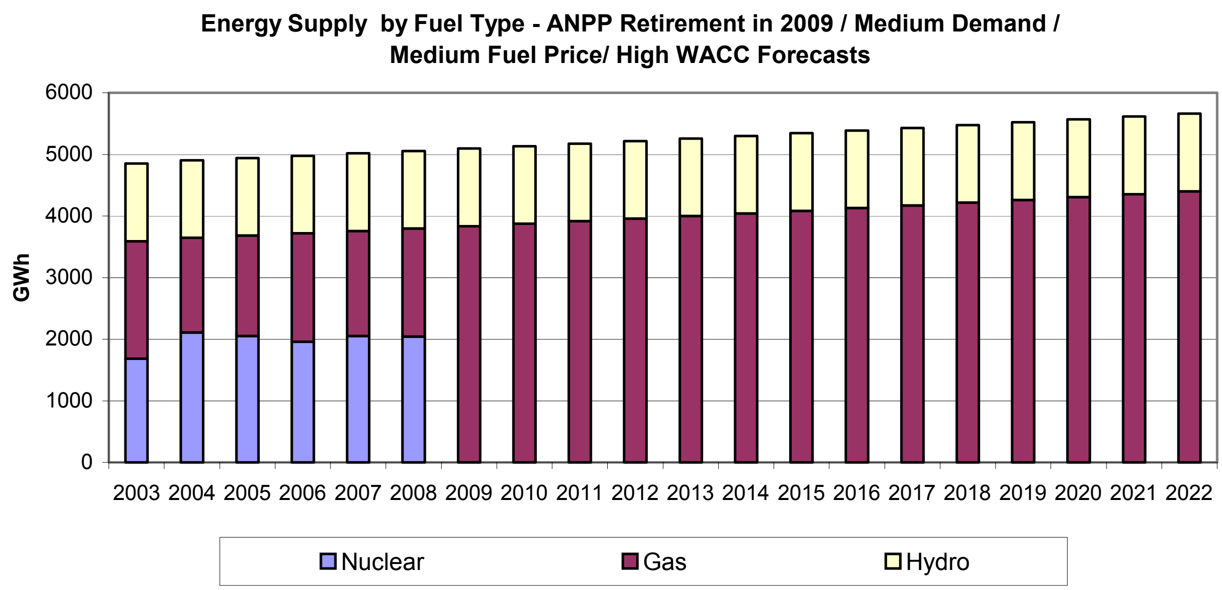
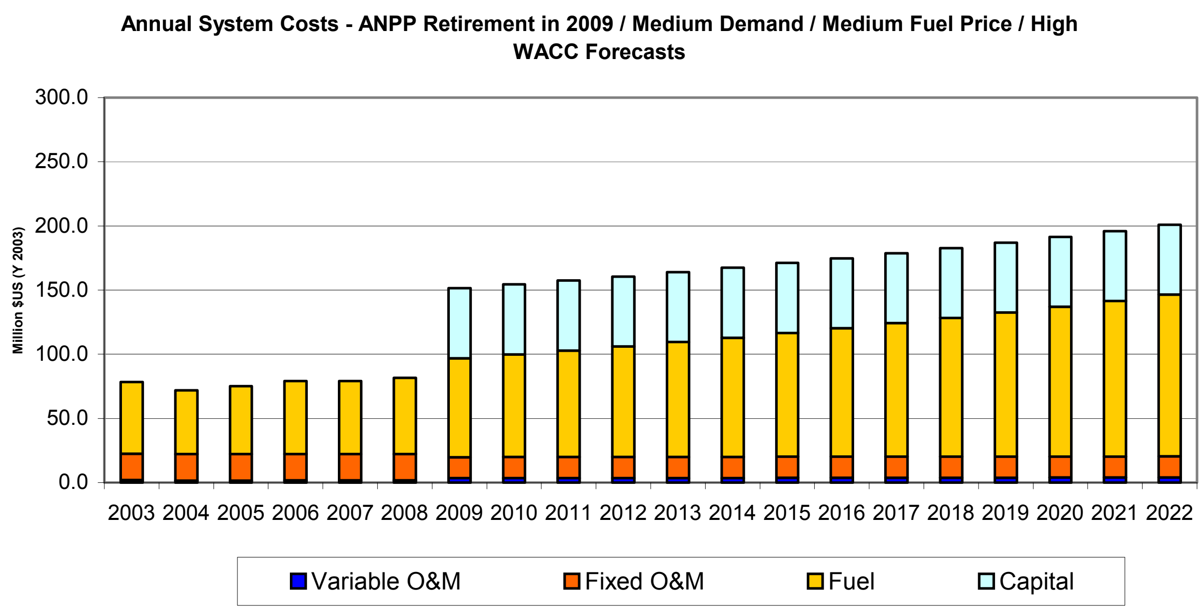


Figure C.21. Annual Generation Costs



CASE 8. LOW DISCOUNT RATE FORECAST

Table C.8. Capacity Additions and Retirements

Year	2003	2006	2007	2008	2009	2016
Gas Other			75 GTS	75 GTS	75 GTS	75 GTS
Nuclear					-346 ANPP Unit 2	
Gas CHP	-2*44 Yerevan CHP 2 & 4 -2*92 Hrazdan CHP 3 & 4	-46 Hrazdan CHP 2	-46 Hrazdan CHP 1			
Coal						
CC						
Hydro						
Total	**-272**	**-46**	**29**	**75**	**-271**	**75**

Note: (+) – Additions
(-) – Retirements

Figure C.22. Generation Capacity Mix

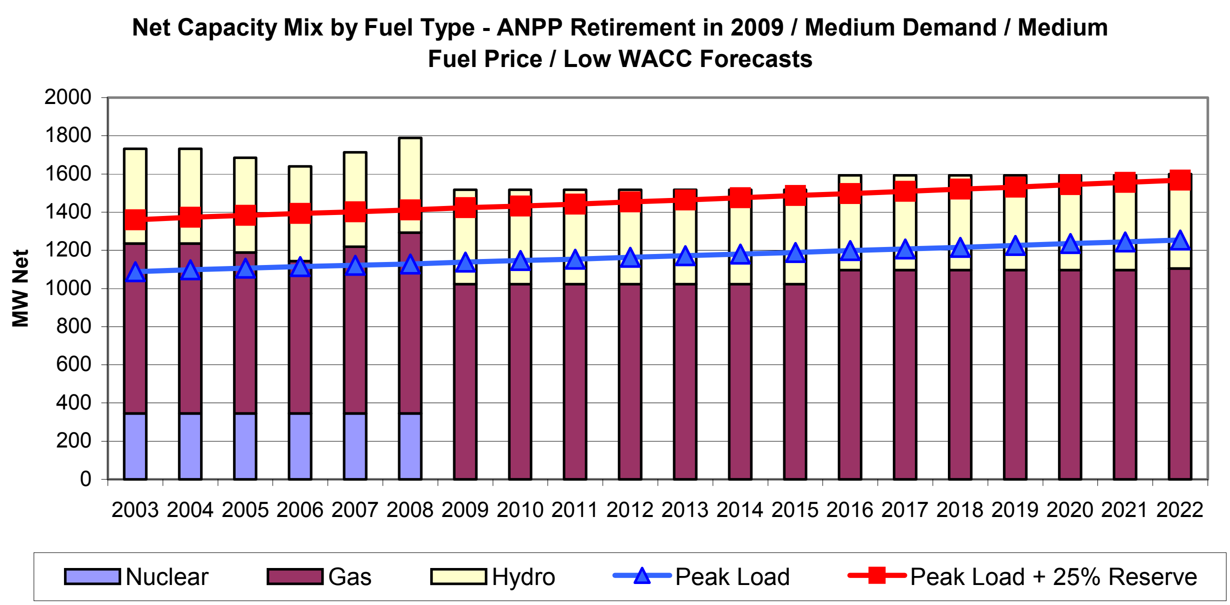


Figure C.23. Generation Energy Mix

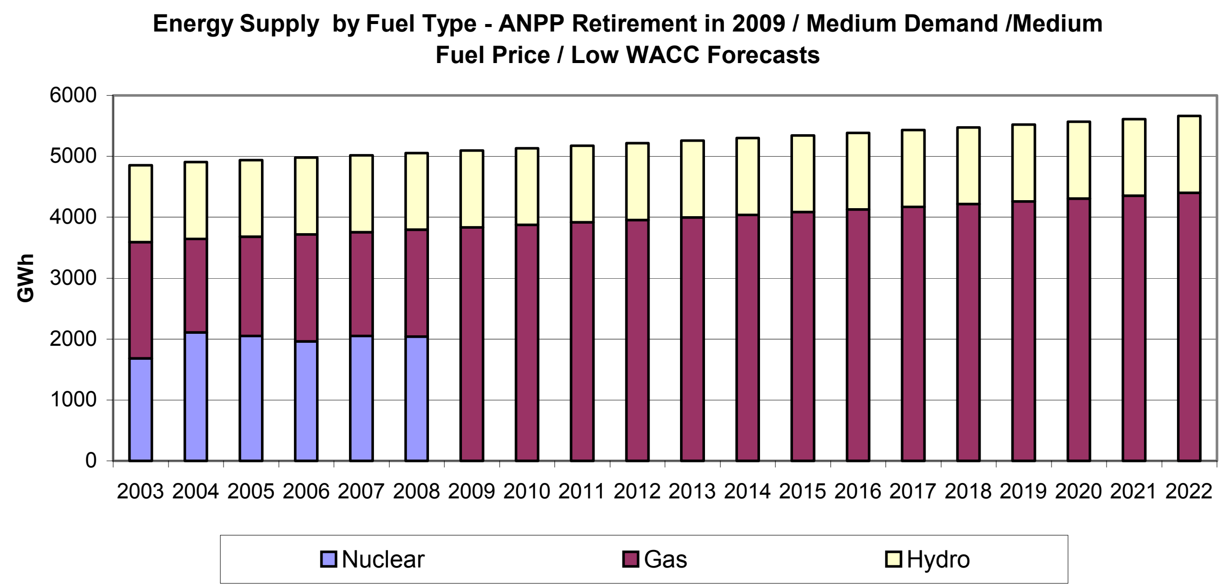
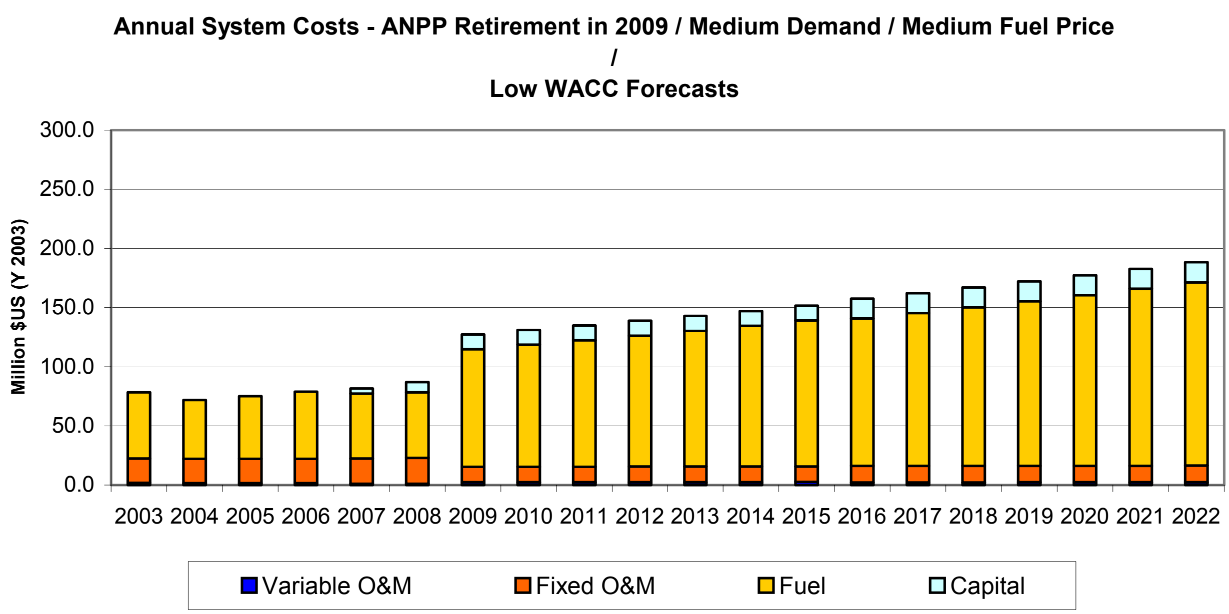


Figure C.24. Annual Generation Costs



CASE 9. 30% RESERVE MARGIN – RELIABILITY

Table C.9. Capacity Additions and Retirements

Year	2003	2006	2007	2008	2009	2010	2017
Gas Other			75 GTS	75 GTS	75 GTS	75 GTS	75 GTS
Nuclear					-346 ANPP Unit 2		
Gas CHP	-2*44 Yerevan CHP 2 & 4 -2*92 Hrazdan CHP 3 & 4	-46 Hrazdan CHP 2	-46 Hrazdan CHP 1				
Coal							
CC							
Hydro							
Total	**-272**	**-46**	**29**	**75**	**-271**	**75**	**75**

Note: (+) – Additions
(-) – Retirements

Figure C.25. Generation Capacity Mix

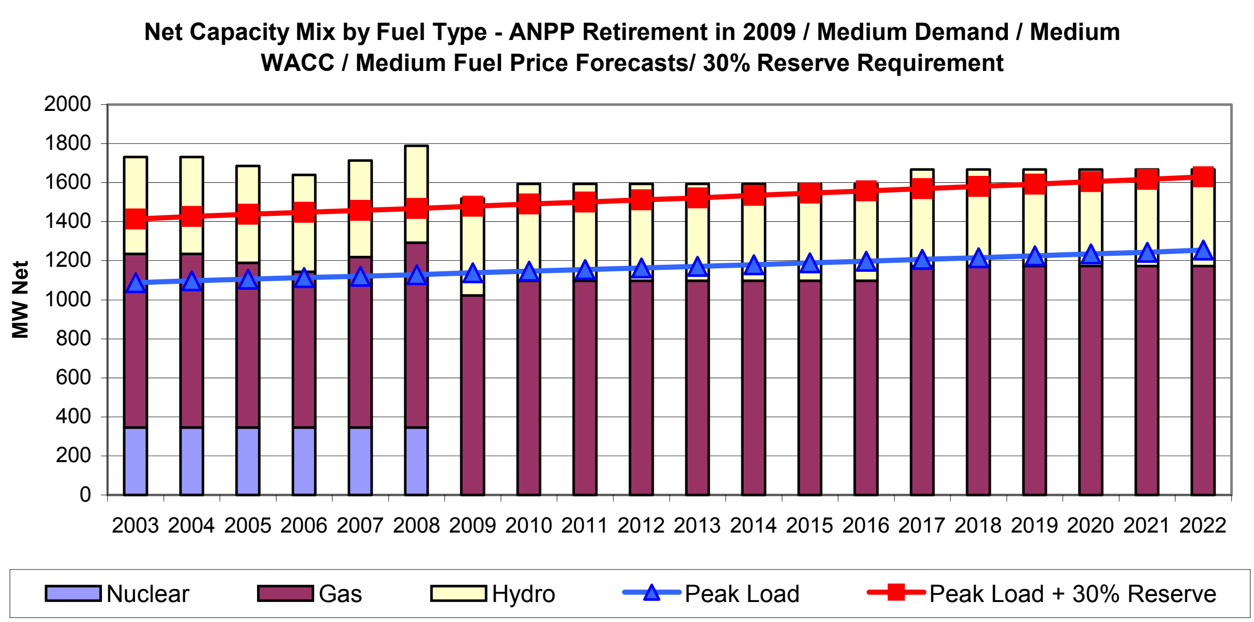


Figure C.26. Generation Energy Mix

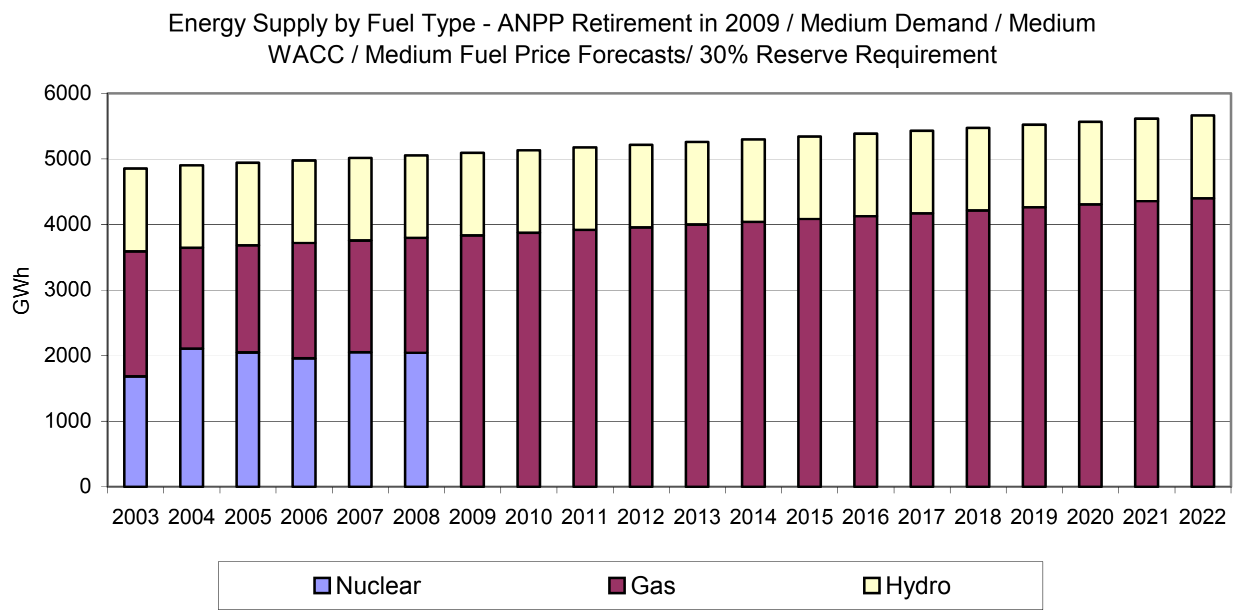
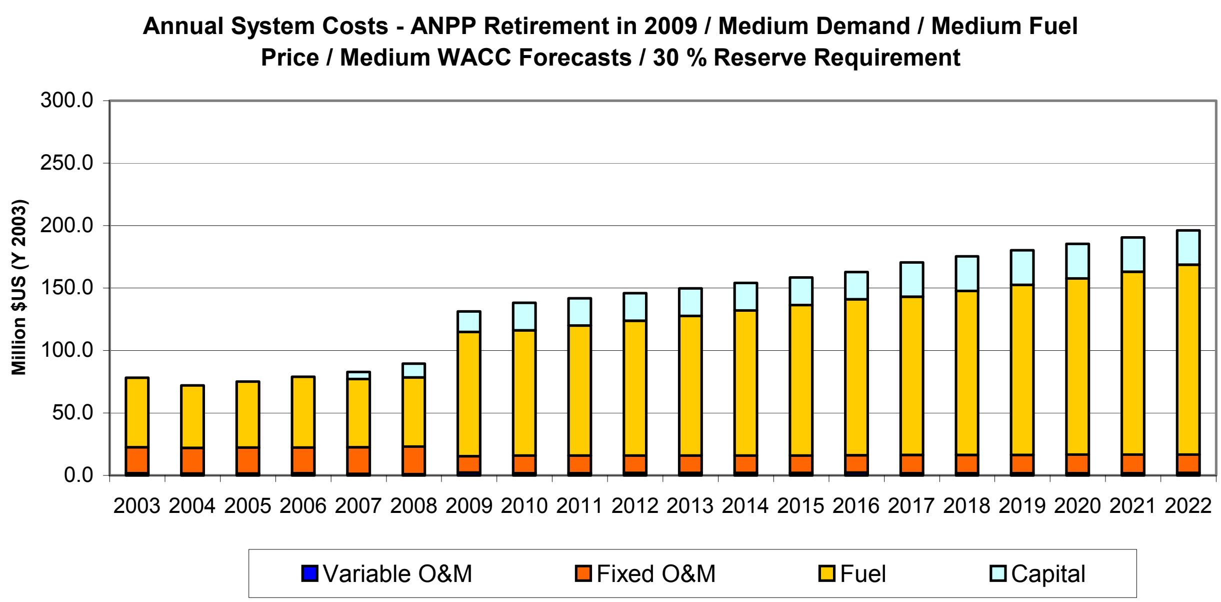


Figure C.27. Annual Generation Costs



CASE 10. STRATEGIC SCENARIO – MEGRI HPP ENFORCEMENT

Table C.10. Capacity Additions and Retirements for the Meghri HPP Enforcement Case

Year	2003	2006	2007	2008	2009	2014	2021
Gas Other				75 GTS	75 GTS	75 GTS	75 GTS
Nuclear					-346 ANPP Unit 2		
Gas CHP	-2*44 Yerevan CHP 2&4 -2*92 Hrazdan CHP 3&4	-46 Hrazdan CHP 2	-46 Hrazdan CHP 1				
Coal							
CC							
Hydro				85 Meghri HPP			
Total	**-272**	**-46**	**-46**	**160**	**-271**	**75**	**75**

Note: (+) – Additions
(-) – Retirements

Figure C.28. Generation Energy Supply

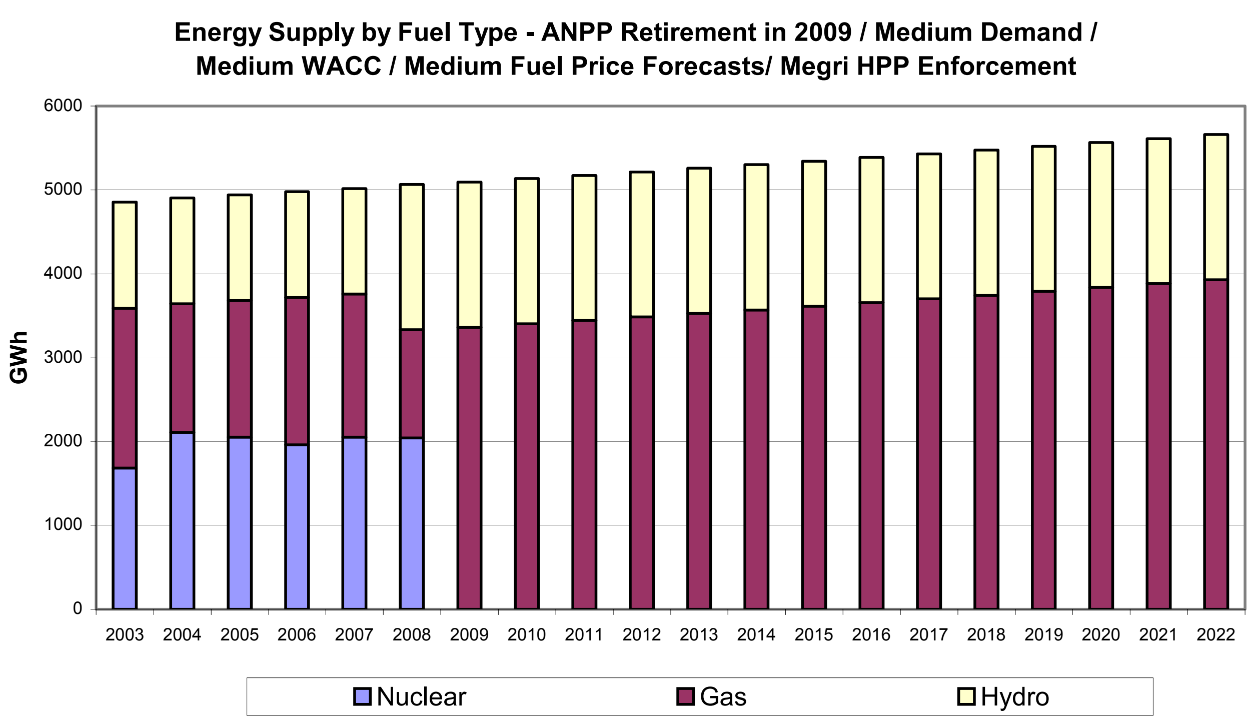


Figure C.29. Generation Capacity by Fuel Type

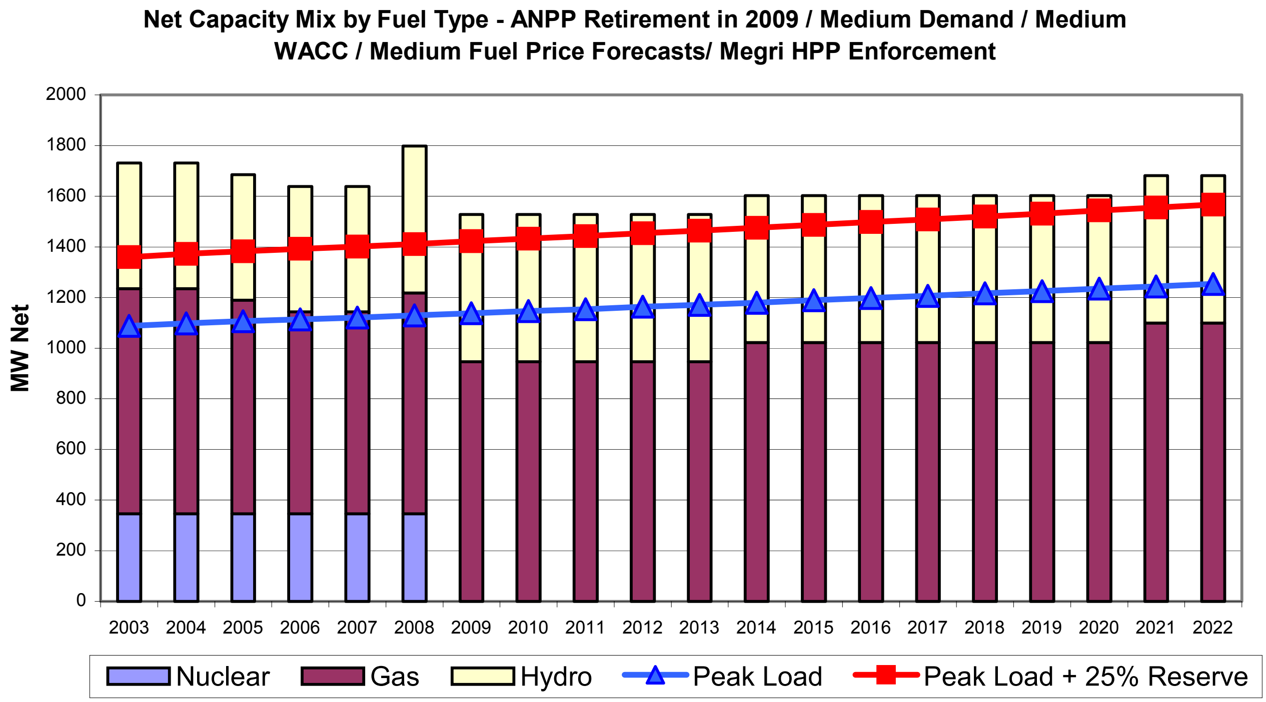


Figure C.30. Annual Generation Costs